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AGRONOMY-RHETORIC EXPERIMENT

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Those interested in obtaining better student writing in non-English courses may be interested in a dual report on the experiment mentioned by Professor Neil Stevens in SCHOOL SCIENCE AND MATHEMATICS, XLVI (1946), 80. I succeeded to the experiment in January of 1946. At the close of the semester I submitted to Professor Stevens and the English Department at the University of Illinois the report given as Section I below. A few days later I read the students' report, which is summarized in Section II.

I

A REPORT ON THE RHETORIC SECTION FOR AGRICULTURE STUDENTS

PURPOSE

This experiment attempted to get agriculture students to transfer, more effectively than is customary, rhetorical knowledge and ability to their other courses.

PROCEDURE

Two sections of Rhetoric 2 were to consist entirely of students enrolled in Agronomy 25. I attended the Agronomy 25 classes from one to five times a week. In an attempt to isolate a single factor in the experiment—the student's professional interest—I followed the normal Rhetoric 2 calendar exactly, emphasizing library research, argumentation, and writing; I made use of agricultural topics for class discussion, for outside reading, and for theme topics. Lest any student object to being forced to write on agronomy or agriculture, I made all strictly agricultural writing assignments optional.

Partly because I mismanaged registration, partly because only about 40 students were enrolled in both Rhetoric 2 and Agronomy 25, I did not succeed in getting two Rhetoric sections of 20 agronomy students each. One section consisted of 14 students, all enrolled in Agronomy 25. The other section consisted of four Agronomy 25 students, three home economics students, and one physical education student.

Specifically, I used agricultural topics in the following ways:

Class discussion: Where current topics in Agronomy 25 fitted the rhetoric calendar, I used these topics in class. For example, I used Professor Sherwood's lecture on the world food problem for a discussion of outlining and organization, the subject "Why Plow?" for a discussion of analysis, various grains for a discussion of definition.

Theme assignments: On every list of theme topics I included current topics from Agronomy 25—e.g., (analysis) a good seed bed, a good seed, a rotation—advantages and disadvantages, plant disease; (argumentation) urging a farmer to adopt new methods or practices; (definition) various grains.

For topics for the research themes, I conferred with Professor Sherwood, seeking topics that he would consider suitable to term papers in agronomy. A partial list follows:

Cotton—types and use; regions and type; quality related to spinning; effect on productivity of Southern soils; boll weevil; history of the gin; effect upon labor
Tobacco—regions and types; culture; history; effect upon soil, state politics, labor
Hemp—growing of; marketing; uses
Rice—culture; types; world crop
Sugar beets—seed problem
Sugar cane—sowing; vegetative reproduction
Lespedezia—history
Wheat—types grown in Balkans; Russian experiments; vernalization or iarivization
England—limitations to economic production; stimulation to intensive agriculture
Adaptation of small grains to extreme northern latitudes
Beneficial effects of experiment station to the agriculture of a state
History of the Department of Agriculture, of some experiment station, of soil conservation, of an agricultural experiment
Yakima Valley (Washington) irrigation
Imperial Valley; agricultural aspects of Boulder Dam
A specific weed
Famous agriculturalists: the Wallaces, the Mumfords, Liberty Hyde Bailey, Luther Burbank

Outside Reading: Three current issues of the *Country Gentleman* provided material for outlining and models for the feature article.

Two oral book reports were required. Besides the books on the list in the Rhetoric Manual, I permitted and recommended the reading of technical books. To make this plan feasible, I required a report on

subject matter only. I prepared a suggestive list from the bibliographies in the Agronomy 25 text *Crop Production Handbook.* The student could read 100 pages of agricultural bulletins in fulfilling this assignment.

Reading agronomy examinations: I read one complete set of agronomy examination papers and a number of isolated papers. Though there was essentially no correlation between the agronomy grade and the rhetorical accuracy (spelling, punctuation, sentence structure) of the papers, I was able to point out vagueness of diction and lack of concrete detail as weaknesses on the poorer papers. Thus "soybeans should be planted as thick as possible" and "The later the planting the higher the yield" hardly qualified as the practical recommendations to the farmer which were asked for.

ESTIMATE

Student reaction to the course was excellent. I think I can safely say that I have never had a class of more eager and cooperative students than the section of all agronomy students. Their common interest and their realization that they were an experiment are probably responsible.

Yet I feel that this experiment indicates that a compulsory segregation of agriculture students is neither necessary nor beneficial. The students responded well to the articles in the *Country Gentleman;* they responded equally well to articles from the rhetoric texts on Ben Franklin, working one's way through college, and techniques of German propaganda. They wrote themes on agricultural topics; more often they selected non-agricultural topics. Students in Agronomy 25, for example, wrote research themes on the UAW, Benito Mussolini, Pancho Villa, Aaron Burr, square dancing, eye operations, etc. Five students read technical books for their first reading report; no student read a technical bock for the second report. The agronomy examination papers failed to reveal an increased awareness of rhetoric in a course other than rhetoric.

I further find against the establishment of separate sections of rhetoric for agriculture students these considerations:

Compulsory segregation would make the agriculture student feel that he was being discriminated against. As expressed by one student, "Hmm, so ag students aren't considered good enough to take the regular course."

Most agriculture students have essentially the same interests that other students have. They are not so technically minded that they wish to devote all their mental energy to a field of specialization. This attitude may be summarized in a student's query during the discussion of research topics: "Must we write on agriculture?" The students look upon the rhetoric course as a means of expressing ideas other than those directly related to technical subjects.

The rhetoric course as now organized at the University of Illinois already provides the student with the opportunity to write on technical subjects, especially

for the research theme, if he so desires. It is true that a rhetoric teacher, whose primary interest is English literature, may not go out of his way to enlist the interests of the agriculture students in his class. The instructor's interests and personality are obviously big variables in any classroom, but only a teacher trained in the specialized vocabulary of agriculture—e.g., "corn lodges poorly," "dished"—*could* do more than the present rhetoric instructors *can* do in teaching agriculture students. It is financially impractical to train any considerable number of rhetoric teachers in agricultural subjects.

Finally, the pressure for improved writing in courses other than rhetoric must come from the instructors in those courses.

II

As the last impromptu theme of the semester I assigned an evaluation of the rhetoric section, telling the students to be completely frank since their papers might help decide whether such sections would be continued. I suggested they tell me why they enrolled in the section, what they expected of it, whether the section met their expectations, what good or bad points they found, what improvements they could suggest, whether the experiment should be continued, etc. In order to encourage honesty, I assured the students that I would not look at their papers until after I had sent their final grades to the registrar.

My report had been unfavorable to the need for separate sections for agriculture students, particularly if segregation were made compulsory. To my complete surprise, the students, without raising the question of compulsion, were overwhelmingly in favor of continuing the experiment. A summary of their points may be useful to anyone interested in conducting similar experiments.

In general, the motives for enrolling did not indicate an interest in rhetoric or in the correlation between rhetoric and agronomy. A number of students enrolled because the experimental sections provided more convenient schedules for them, a number because the experimental sections alone were available at the time they registered ("I was shoved into the course"). An equal number enrolled because they felt rhetoric, and even agronomy, would be easier. A few feared teachers who "object to agriculture topics." A very few did not wish to "get too far from agriculture."

The "isolated factor"—professional interest—received favorable comment. The students generally felt that the correlation between rhetoric and agriculture created interest and made their theme-writing a less difficult and more rewarding task. The necessary variable—the instructor—also received considerable comment (". . . it is a decided advantage to the student to have someone that is sympathetic with his cause"; "I do know you are more concerned with teaching rhetoric than in learning about agriculture"). One student who had taken Rhetoric I four times was violent on the subject of unsympathetic instructors. Several remarked that the ability of the

instructor was more important than segregation. Other points favorably commented on included the study of agronomy examination papers, the smallness of the class, the use of a periodical for readings.

Though all students recommended the continuance of the experiment, one student definitely preferred non-segregated sections where he might exchange ideas with non-agriculture students; another cited the possibility of such a disadvantage to segregated sections. A third student, though in Agronomy 25, found the course of no benefit to him because he had no interest in agronomy.

The suggestions for improvement concerned both the agriculture-rhetoric correlation and the course as rhetoric course. Several students suggested more study of agronomy examination papers ("maybe a rhetoric grade on all agronomy papers would be helpful, but this would probably be severely criticized by the students"). One student suggested that agricultural economics would correlate more successfully with rhetoric than agronomy does. Several suggested that, since the course was not and should not be tied down to agronomy, it should be open to all agriculture students. One student suggested a poll, early in the semester, to determine student interests as a guide to the work of the semester. Concerning the course simply as rhetoric, one student wanted more assistance in sentence structure and vocabulary, another wanted more time devoted to argumentation and the study of the library, several wanted more impromptu themes.

III

One cannot feel that the experiment failed completely in its purpose when a student, without hope of reward, writes, "I naturally resent rhetoric, but this course has helped me considerably in understanding its need and use throughout our lives"; yet one continues to wonder. When these impromptu themes were not to be graded for rhetorical merit, they were not good.

TEACHING AIDS CATALOGUE ANNOUNCED BY WESTINGHOUSE

An 18-page Teaching Aids Catalogue recently announced by the School Service Department of the Westinghouse Electric Corporation describes numerous charts, posters, and booklets which are available for distribution to high school teachers.

These Teaching Aids are of great value in bridging the gap between the textbook and the student's keen interest in current developments. Covering a wide range of subjects (nuclear physics, science, home making, education, agriculture, industrial arts, and radio), the materials described in the catalogue can be obtained free of charge or for a nominal sum. Each catalogue contains order blanks for use in requesting these materials.

Teachers can secure copies of the Teaching Aids Catalogue through the School Service Department, Westinghouse Electric Corporation, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pa.

CAN YOU SOLVE A DICTOFORM?

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Presented here is a new type of mental recreation, called a dictoform, which combines many of the features of cross-word puzzles, anagrams, and deciphering of cryptograms. Much more than knowledge of vocabulary is needed to solve a dictoform. Involved is an understanding of the many possible permutations that may be formed from the letters of a given word. Much careful thinking and perseverance are required to complete the solution.

At first glance a dictoform closely resembles a cross-word puzzle. Horizontal and vertical words are used, each one indicated by a number. As a clue to each word in the dictoform, a definition, or description, is provided. The chief difference is that, when the word has been identified, it may be written into the proper space using any possible permutation of its letters as in ordinary anagrams. Thus, if the definition calls for a four-letter word meaning, "a prefix for 1000 used in the metric system," the word may be set down as KILO, KOIL, LIKO, or any other of the 24 possible arrangements. Which one is correct, will not be immediately apparent. Here is where considerable ingenuity may be necessary, for each dictoform has been drawn up so that there will be, in the final analysis, only one way to write out each word so that all the words will fit together.

A small dictoform will be shown and solved in detail.

DICTOFORM (Sample)

	5	6	7	8
1				
2				
3				
4				

Horizontal Words

1. The smallest particle into which matter can be divided and retain its chemical identity.
2. The name given to those years that contain 366 days.
3. The technical name given to the diameter of an engine cylinder.
4. A Latin term meaning "to cut"; found in many geometric words.

Vertical Words

5. An algebraic name for each of the two parts that make up a binomial.
6. A black mineral used for fuel, formed by the decomposition of vegetable matter.
7. The sound of a drum.
8. A position assumed by a person for effect; a studied attitude.

Solution

The words are probably as follows: (1) atom, (2) leap, (3) bore, (4) sect, (5) term, (6) coal, (7) beat, and (8) pose. Of course it is not yet certain that these are the correct words, but if any are wrong the error will be disclosed by the difficulty encountered in trying to fit them into the dictoform. Assuming they are correct, the upper, left-hand letter can be either M or T, since these letters are common to "atom" and "term." The next square to the right can contain either A or O, since both are found in "atom" and "coal." The third square at the top can similarly be either A or T. The upper, right-hand letter must be O, since this is the only letter common to "atom" and "pose." Looking back it is now certain that the upper, left-hand letter must be M, since no other letter in the top row could be M. By continuing this process of deductive logic, the following solution can be determined as the only arrangement that satisfies all the conditions:

	5	6	7	8
1	M	A	T	O
2	E	L	A	P
3	R	O	B	E
4	T	C	E	S

Submitted for solution is a larger, slightly more difficult, dictoform. The five-letter words used are drawn mostly from mathematics and science. Next month's issue will have the solution, and contain a second dictoform. If interest warrants, the series will be continued.

DICTOFORM

No. 1

	6	7	8	9	10
1					
2					
3					
4					
5					

Horizontal Words

1. The number of points needed to determine a circle.

Vertical Words

6. The number of sides bounding a polygon whose interior angles total

2. The verb corresponding to the noun, "proof."

3. A geometric figure composed of two straight lines whose size is usually measured in degrees.

4. The first name of a radio singer whose last name is "Shore."

5. Smallest; lowest; the superlative for little.

1080 degrees.

7. The number of carbon atoms in a molecule of heptane.

8. A device for finding range and direction using reflected radio waves.

9. The name given to a flat surface, especially in geometry.

10. A building consisting mostly of rooms for rent to transient guests.

TRAINED FISH

Scientists at the University of Wisconsin are using "trained fish" to detect industrial pollutants in water.

Working with the bluntnose minnow, Wisconsin scientists proved some months ago that fish have an exceptionally good sense of smell. Now the scientists are putting the minnows to work.

What the minnows do, essentially, is detect phenols in extremely low concentrations. Phenols are dumped into natural waters as waste products from many types of industries, and when picked up by purification plants give an unpleasant taste and smell to the purified water used for drinking and other purposes in cities.

"The phenols combine with the chlorine used in purification," explained Warren Wisby, research assistant to Arthur Hasler, professor of zoology. "They form chlorophenol compounds which though harmless give water an unpleasant taste and smell."

Neither phenols nor chlorine in the amounts they usually occur will give water the characteristic objectional taste—but the same quantity of chlorophenols will, say William Lea and Gerard Rohlich, professors of sanitary engineering and co-advisors on the project.

Purification plants hitherto were unable to detect small amounts of phenol in water picked up for chlorination and use in city water supplies until it was too late—until consumers complained the water had a bad taste.

But Wisby's trained minnows will react in a minute to water containing phenol, much quicker than any known chemical methods.

The work stems from Theodore J. Walker's discovery in the same Wisconsin "Lake Laboratory" that he could train minnows to expect food whenever a certain odor was introduced into the aquarium. He also trained them to expect an electric shock when an "opposite" odor was introduced.

The minnows would rush into—or away from—the food trough whenever the odors were introduced.

Wisby has found they will do the same thing when phenols are filtered into the aquarium water.

When minnows smell the phenol they rush to the place where they have been trained to find food. As an additional check, Wisby has trained other minnows to fear an electric shock if they venture into the feeding trough while smelling phenol in the water.

"We don't know definitely as yet whether the trained minnows will be useful detectors of phenols for water purification plants," Wisby said, "but all indications are that they will."

This is the way it would work: the purification plant would take a sample of water periodically to dump into the aquarium. If one group of minnows rush for the food trough, and the other group stays as far away as they can, then it would be almost certain that phenols are being taken into the purification plant.

Another advantage of the "minnow system" is that their noses are so sensitive they can detect phenol long before it reaches a concentration which can be tasted by humans.

ATOMIC STUDY CURVE

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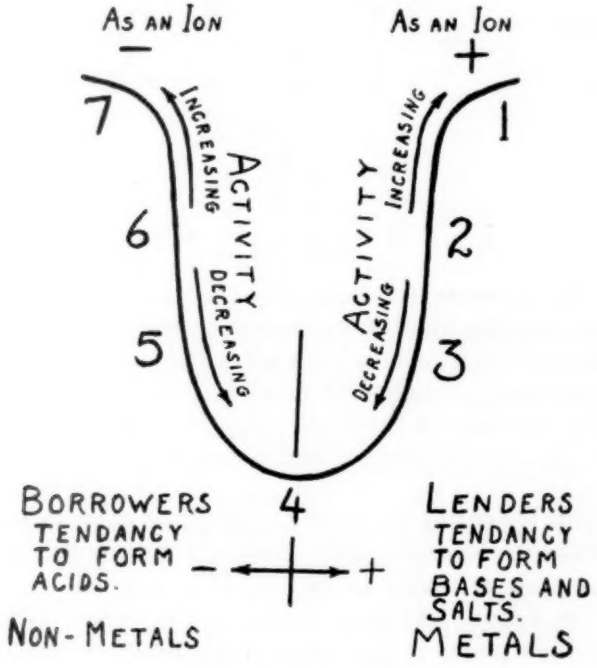
PREFACE

The purpose of this curve is to aid the student of elementary chemistry to obtain a more simple and understanding conception of the simple atoms.

To most students, the verbal discussion of atomic structure appears to be an endless chain of words due to its lenghty nature. Instructors have found it difficult in seeking an effective means of reaching the imagination of the students and as a result, a hazy and confused knowledge of the theory is brought about.

DESCRIPTION OF THE STUDY CURVE



It has been proven that with the aid or use of some visible object, subject matter has become less difficult. It is through the power of mental conception of principles that students, not only in science but also in various other fields of study, have been able to understand and retain the fundamental principles.

This curve does not serve the same purpose as Mendeljeff's Periodic

Table but does lead to a better understanding of the elements as grouped by Mendeljeff.

It offers an easy method of remembering how elements will react in normal reactions. Formation of compounds becomes understandable in a very short period of time.

During the ensuing pages an effort will be made to explain the function of the curve and how it may be used to good advantage during the preliminary study of the atom.

The numbers one to seven, as shown on the curve, represent the number of electrons found in the outermost ring of the atom. These electrons, as we know, determine the characteristics of the atom. This fact may be visibly indicated upon a curved line in such manner as to present a vivid method of remembering facts about the atom.

To illustrate the placement of an atom upon the curve, let us use the following elements:

Element	Symbol	Number of Electrons in outer ring
Sodium	Na	1
Magnesium	Mg	2
Aluminum	Al	3
Carbon	C	4
Nitrogen	N	5
Oxygen	O	6
Fluorine	F	7

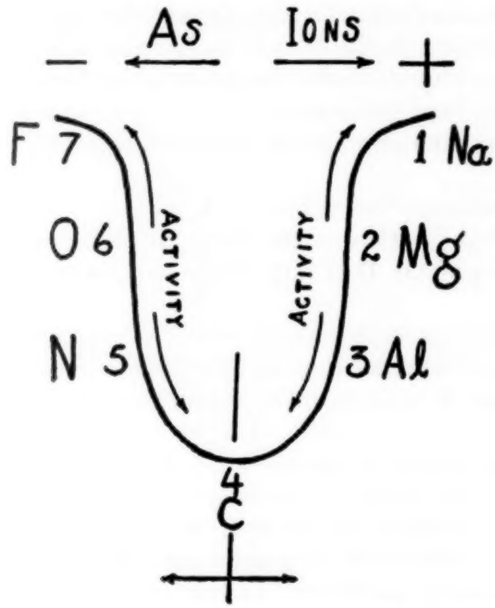
Each of the elements listed above is placed upon the curve in the position carrying the number equivalent to the number of electrons found in the outer ring, such as: Na takes the first position, Mg takes the second position, Al takes the third position, etc.

With the placement of the elements in this manner, we may now proceed to discuss the positive and negative properties of the elements.

All elements appearing on the right side of the curve contain one to three electrons in the outer rings. These are classified as metals and will carry a positive charge as an ion. This is shown by the +sign placed in the upper right-hand corner of the curve. The elements which take their places in any one of these positions will be lenders and will lend their single electron to another atom during a reaction and will retain a positive charge as an ion. It may be noted that these elements are metals and generally form bases and salts which bear the name of the metallic ion.

On the left side of the curve we find all the atoms containing five to seven electrons in the outer ring. It is known that these atoms containing these numbers of electrons need additional electrons to com-

plete the outer ring and possess the tendency to borrow rather than to loan electrons. Atoms possessing this tendency are known as borrowers and retain a negative charge as an ion. This is signified by the sign appearing in upper left-hand corner of the curve. These elements are non-metals and generally react to form acids.



At the lowest point of the curve we find the number four position. In this position all elements possessing four electrons in the outer ring are placed. If, as in the case of carbon, the valence is plus or minus four the elements either react as a metal or a non-metal. This point on the curve may be thought of as the point of indifference depending upon the conditions of the reaction. It may be noted that at this point a definite line of division occurs which determines whether or not an atom becomes a metal or a non-metal.

The descending right and left sides of the curve denote a decrease in activity and the ascending sides denote an increase in activity. For example, consider the following elements:

Na+1, occupies the first position and is very active. Mg+2, occupies the second position and is active but not as active as Na. Al+3, occupies the third position and is fairly active. C+ or −4, occupies the fourth position and is indifferent as to its activity. This position denotes the least point of activity. In this fourth position, the elements occupying this position can either react as a metal or a non-metal depending upon the conditions of the reaction.

It is true, however, that any one of the positions described on the curve may be occupied by elements having the same valence but differing greatly in their activity. It may be well to use as examples Na and Ag. Both carry a valence of +1 but differ in chemical activity. This difference may be noted by the consideration of the arrangement as set up in the electrochemical series.

The positions on the curve also suggest that the elements taking the upper positions of the curve, both right and left sides, react readily to form compounds and those taking the lower positions react rather slowly to form compounds.

The following examples may be used to illustrate the practical use of the curve.

1. Sodium—Na—valence +1.

Occupies the first position on the curve. It carries a positive charge as an ion. It is a metal. It is very active and forms a base and many salts.

2. Chlorine—Cl—valence −1. (Seven electrons.)

Occupies the seventh position on the curve. It carries a negative charge as an ion. It is a non-metal. It forms an acid. It is a very active element.

3. Carbon—C—valence + or −4.

Occupies the fourth position, the lowest on the curve. It may carry a negative or a positive charge as an ion. It may react either as a metal or a non-metal depending upon the nature of the reaction. It is not very active as an element. In this position it either becomes a lender or a borrower, its indifference is obvious.

4. Platinum—Pt—valence +4.

Occupies fourth position, it carries a positive charge as an ion. It is not a very active metal. It does not form bases or salts easily. It is indifferent towards other elements.

Up to this point the electrochemical series of elements was used as a guide in order that a general idea might be had as to the comparative activity of the elements concerned. In order that a more concise understanding might be had, a regrouping according to the valences might be arranged in the following manner:

Group	Valence	Elements
1	+1	Li, K, Na, Cu, Ag.
2	+2	Mg, Zn, Fe, Cu.
3	+3	Al, Fe, P, Cr, Au.
4	+ or −4	C, Pt.

In group 1 we find those elements having a valence of +1 and their activity decreasing according to their position in the electrochemical series.

In group 2 we find those elements having a valence of +2 and their activity decreasing according to their position in the series.

In groups 3 and 4 we find a similar arrangement of the elements.

The non-metallic groups will contain elements such as fluorine, chlorine, bromine, iodine, oxygen, sulfur and many other negatively charged elements.

It is possible to group these elements into so-called activity groups in order to obtain a more effective understanding of the differences existing. This arrangement again will serve the same purpose as mentioned in the preceding paragraphs in reference to the metals.

The following groupings may be considered to clarify the thought.

Group	Valence	Elements
1	−1	F, Cl, Br, I.
2	−2	O, S.
3	−3	P, N.

All the groups are not complete in so far as all the elements are concerned, they may be completed at the discretion of the individual.

These groupings are accurate in respect to the electrochemical series and they will aid the student to realize that even though Na and Ag have a +1 valence, there is a distinct difference in their individual activity.

During the study of ionization, the curve displays the sign to be carried as an ion. These signs are placed above the curve to the left and right sides. The number of charges carried is determined by the valence carried as an atom.

The curve has proven itself to be an effective method in obtaining a clear conception of the atoms as to their individual characteristics and behavior as atoms and ions.

MOTION PICTURE AND SLIDE FILM INDEX ANNOUNCED BY WESTINGHOUSE

A new index of the sound motion pictures and slide films which can be loaned to schools has been prepared by the School Service Department of the Westinghouse Electric Corporation. These materials can be borrowed free-of-charge except for transportation costs.

The motion pictures and films described in the catalogue cover a wide range of subjects and can be used for either general assembly programs or for home economics, industrial arts, salesmanship, science, and social science classes. A small section of the catalogue describes various teaching-aid charts and transcriptions which are also available in connection with these pictures and films. For convenience in requesting the films and supplementary material, an order blank is included with each catalogue.

Teachers can secure copies of the index, "Westinghouse Sound Motion Pictures and Slide Films for School Use," by writing to the School Service Department, Westinghouse Electric Corporation, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pa.

AN APPROXIMATE CONSTRUCTION FOR A REGULAR ENNEAGON

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The problem of constructing a regular enneagon is equivalent to that of trisecting a 30° angle, for the central angle subtended by one side of a regular enneagon is $40° = 30° + \frac{1}{3}(30°)$. We may accomplish a relatively simple and relatively accurate trisection of a 30° angle, using only straight edge and compasses, as follows:

Let angle AOB = 30°, take C, any point on the bisector of angle AOB, and draw AB through C perpendicular to OC; draw semicircle ADEB on AB as diameter and lying on the side of AB which is toward O; mark off D and E on this semicircle so that AD = BE = AC; take F on chord ED such that $EF = \frac{1}{4}ED$. Then OF approximately trisects angle AOB.

For, if we set OA = 1 and let G be the intersection of OC with DE, we readily find

$$\tan FOC = \frac{FG}{OG} = \frac{\frac{1}{4}AC}{OC - GC} = \frac{\frac{1}{4}\sin 15°}{\cos 15° - \frac{1}{2}\sqrt{3}\sin 15°} = 0.0872289.$$

Therefore

$$\text{angle } FOC = 4°\ 59'\ 07''.$$

For perfect trisection we should, of course, have angle $FOC = 5°$.

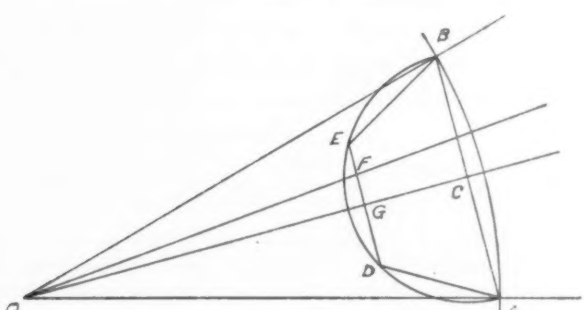

FIG. 1. Construction of regular enneagon.

LARGEST ENROLLMENTS BY INSTITUTION

The 10 institutions with the largest enrollments reported are: New York University, 47,647; University of California, 43,469; City College of New York, 28,567; Columbia University, 28,000; University of Minnesota, 27,243; University of Illinois, 25,920; Ohio State University, 23,929; Northwestern University, 23,788; University of Indiana, 23,131; University of Southern California, 22,740.

DEMONSTRATION EQUIPMENT—
I. ELECTRIC WIRING

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In this article, the authors will describe a type of demonstration equipment that has proven very effective in teaching students some of the principles of electricity and more specifically, the basic principles of wiring.

For lecture demonstration as well as for laboratory exercises, it is usually customary to scatter the various batteries, buzzers, switches, lights, and transformers over a wide area. Such haphazard arrangements are usually confusing enough but when one adds to that a miscellaneous collection of long and short wires, some of which are bare and others with unraveling strings of insulation, the total mass becomes a puzzle for even the instructor to understand—let alone, the poor average student.

When wiring is to be done in a house or in a radio, the equipment is always securely fastened in place so actually the haphazard maze of wires and electrical equipment in laboratory or on lecture table cannot be excused on the basis that it is a realistic situation. Moreover, an experienced electrician and electrical service worker in spite of all his experience attacks his work systematically keeping in mind a "picture" of the diagram which is being followed. This would seem to be another reason for wanting to demonstrate the electric circuit in a systematic and suitable fashion.

The electrical circuits pictured in textbooks are laid out very carefully so that the path of the connections can be recognized clearly and quickly. Therefore if it is sensible to use these systematic methods for textbook teaching, then certainly no additional hazard or hurdle should be placed in the way of the student who is being introduced to electricity for the first time. The lecture table lay-out of wiring should bear some resemblance to the simplicity of a pictured circuit diagram.

With the idea of simplifying the teaching of electricity and of electrical circuits, several different electrical display boards have been built. Undoubtedly other teachers have used similar boards in the past. This report neither claims these to be the first of the kind nor the best. Its sole purpose is to describe a method of demonstration that may not have occurred to some teachers. The usefulness of the

method can be attested to by the fact that these boards are continuing to be used and new ones are being constructed to take the place of those that have been worn out. Moreover, new and more elaborate pieces of equipment are being adapted to this display board technique.

The board illustrated in Figure 1 and Figure 2 has been built by two boys in an advanced science class. This will show that even the teacher without the mechanical and carpentry skill required can have these display units constructed according to his planning and lay-out. The board illustrated has the following items:

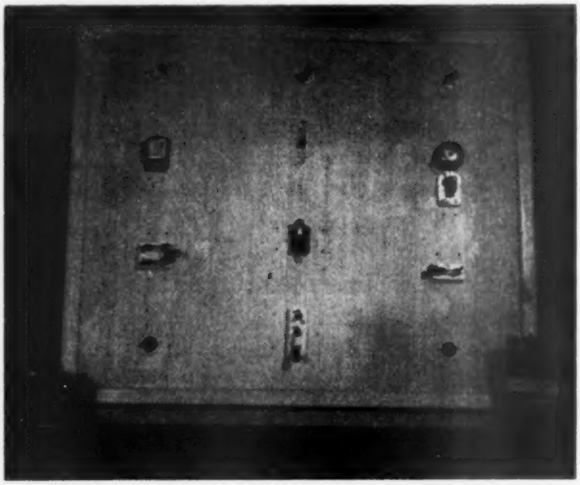

FIG. 1. Demonstration Boards for electrical circuits

1) three sockets such as radio supply houses sell for pilot light fittings.
2) two door bell buttons.
3) three knife switches.
4) one door bell.
5) one buzzer.
6) two electric house wiring switches.
7) A transformer is shown but this has not been attached to this particular board.

The connections to the sockets, switches and buzzers have been brought out to Fahnstock clips. This makes it possible to attach equipment without twisting binding posts. The connecting wires are prepared in lengths 1 foot, 2 feet, and 2½ feet long. Stranded wire is used for it will withstand bending even though it may appear to have the disadvantage of its frayed ends being hard to fasten. This

latter problem is overcome however by twisting the stranded ends and running solder over them until the ends resemble a piece of solid wire. It is also helpful in tracing circuits to use wires having different colors of insulation. Wires with very durable plastic insulation are available in nearly a dozen colors and this proves very satisfactory.

The storage of boards such as this one does not present a problem. Even with the attached equipment they are thin enough to be stored in a small space. Moreover, they are attractive enough to be hung on the wall for permanent exhibit when not in use. The storage of equip-

FIG. 2. The Demonstration Board being used in class

ment on boards also has the advantage that it reduces loss or damage to equipment.

An instructor who has always tried to explain electrical circuits by his scatter layouts on the lecture table will be pleasantly surprised to find that all students can now watch his every step in wiring a circuit. With the equipment visible to the entire class, other new teaching techniques become practicable. Contests between different groups in the room become possible for all the students can watch as each member of a team tries to solve a circuit problem proposed by some member of the opposing team. Sufficient interest can be developed as a result of this competition that greater achievement can be brought about. Other boards can be built in which the type of switches and

circuit are hidden from view and it then becomes the student's problem to describe the circuit that is being used.

Other boards that have been built use circuits such as the following:

1) simple one tube radio receiver.
2) simple one tube radio transmitter.
3) audio or speech amplifier.
4) rectifier and filter circuit with multi-voltage transformer, voltage divider, etc.
5) photoelectric cell circuit.
6) resistance bridge circuits.
7) telephone circuits.
8) telegraph circuit with relays, etc.

In circuits such as these mentioned above, the electrical sympol for each instrument is drawn on the board beside the article itself. In this way, the student is taught the association between the symbol which appears in electrical diagrams, the instrument itself, and the function of the instrument. Connecting clips are brought out at every conceivable part of these cricuits so that the students can test the voltage, resistances, and current at various points and also so that they can wire other pieces of equipment into the circuit and short-circuit others. The laboratory or lecture room with an oscilloscope will find that viewing the radio signal at various places in a radio circuit makes the function of the radio parts much more meaningful.

Many applications and uses of the demonstration boards will occur to the teacher who tries them. As has already been suggested, the measurement of student progress can be much more quickly accomplished on a board of this type then by using the hodge-podge of equipment so often employed. Those who like to test by means of performance rather than depending only upon paper-pencil tests will find that the demonstration boards greatly facilitate performance testing.

Notice to Readers

If there are those who have prepared demonstration type boards for other branches of physics, or for chemistry, biology, and general science, send a glossy print photograph of the apparatus along with a short description and we shall be glad to consider it for publication.

SECTIONAL EDITOR

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PUTTING MEANING INTO ALGEBRAIC CONCEPTS AND RELATIONSHIPS

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INTRODUCTION

In a previous article we suggested some ways of putting more meaning into certain geometric concepts and relationships. A common characteristic of these "ways" was the inclusion of student experiences consisting of "overt acts that a child has performed, or has observed someone else perform, while working with a number of objects directly presented to the senses" (1). The filling of a cylindrical container with a conical one of the same base and altitude in order to determine the formula for the volume of the cone was given as an illustration of one of these "overt acts." The algebraic symbols in the formula played a secondary role since the principal purpose was the determination of the geometric relationship.

While it is true that certain algebraic concepts and relationships can be made more meaningful through the use of guided "overt acts" on real objects, it is extremely doubtful that the initial treatment of all algebraic ideas and processes can or should be made to depend upon these kinaesthetic experiences. After all, the symbols of elementary algebra refer to numbers, to the operations performed on them, and to the relationships existing between them. For example, in the formula $P=2L+2W$, the letters refer to numbers, the $+$ sign to an operation and the $=$ sign to a relationship. Intrinsically, algebra is a study of the behavior of these symbols under the influence of certain operations. This is not to deny that the significance of formulas is enriched by application of them to the world of reality. It does imply, however, that full attention to algebra for its own sake must be given, if it is to develop into a sharp intellectual tool for the student as he faces problems containing quantitative relationships. In this connection, what John Dewey said of number study applies also to algebra: "It is as true of arithmetic as it is of poetry that in some place and at some time it ought to be a good to be appreciated on its own account—just as an enjoyable experience, in short. If it is not, then when the time and place come for it to be used as a means or instrumentality, it will be in just that much handicapped. Never having been realized or appreciated for itself, one will miss something of its capacity as a resource for other ends." (2).

The simple idea toward which we are leading is that very often the best way of making algebra more meaningful is to base an understanding of it on "overt acts" performed on numbers rather than on "objects directly presented to the senses." There comes a time in mental development when constant reversion to primitive experiences with the concrete is educationally wasteful and absurd. The time arrives when it is not necessary to have blocks on hand to obtain the sum of 3 and 5. More specifically, by the time the student reaches the ninth grade, number relations with integers and fractions should be as familiar as those between groups of real objects. At this stage of his development, the student should have been weaned away from extreme dependence on kindergarten procedures for attaining security about common number ideas and operations.

It is the purpose of this paper to describe various ways of making algebraic concepts, operations, and relationships more meaningful through constant reference to arithmetical ideas, by frequent use of geometric and graphic diagrams and by occasional attention to "overt acts" on "objects directly presented to the senses." Good textbooks and alert teachers have used most of these devices before. However, there is value in the mobilization of these, for there is the opportunity to make the practices of several teachers the possessions of each individual. Such pooling of resources is essential if we are to make an organized attack on the problem of putting more meaning into elementary algebra.

The Meaning of Squares and Cubes

Ball points out that Pythagoras treated many of his arithmetical questions by geometrical methods (3). Some numbers were represented by line segments, the product of two numbers was called a plane number, and the product of three numbers was called a solid number. If a number had an exact square root, it was called a square and represented by that geometric figure. If a number had an exact cube root, it was called a cube and pictured as such. In both of these cases the roots were called sides.

In teaching beginning algebra the square of a or of $2a$ can be portrayed as the area of a square of side a or $2a$. The cubing of these quantities can be interpreted as resulting in the volume of a cube. The quantity $2a$ itself can be pictured as the sum of two line segments of length a. The product of a^2 and a can be revealed as the volume of a rectangular solid or cube having a^2 for a base and a for an altitude. One danger in these procedures is that students will be stumped in illustrating a^4 and a^5. In such cases, it is necessary to point out to them that the a's are really numbers which sometimes can be geometrically

interpreted but not always, Mathematics can frequently be applied and illustrated but its life does not depend on such treatment.

The Meaning of Similar and Dissimilar Terms

The concept of similar terms permeates a large part of mathematics. It is one of the threads that bind arithmetic and algebra into one organism.

1. The sum of 3 and 5 can be considered as the sum of 3 ones and 5 ones. The common element is the "one." Similar remarks apply to the sum and difference of 0.3 and 0.5, of 3/8 and 5/8, of $3/a$ and $5/a$, of $x(a+b)$ and $y(a+b)$, of $3x^2$ and $5x^2$ and of $3\sqrt{a}$ and $5\sqrt{a}$.
   Likewise, in the case of dissimilar terms, the sum of 35 and 27 involves the combining of 3 tens and 2 tens as well as 5 ones and 7 ones. Similar remarks apply to the sum of 0.35 and 0.27, of 2 1/8 and 3 5/8, of $3a$ and $5b$, and $3a^2$ and $2a^3$ and of $3\sqrt{a}$ and $5\sqrt{a}$.
2. The geometric interpretation given above can be used to reinforce these ideas. Line segments of different lengths for a and b can be used to portray the sum of $3a$, $5b$, $2a$ and $6b$. Squares of different sizes can help in the proper treatment of the sum of $3a^2$, $5b^2$, and $2a^2$ and $6b^2$. Squares and cubes can be used to show the absurdity of adding the exponents in dealing with the sum of $3a^2$, $3a^3$, $2a^3$ and $6b^3$.

Operations on Polynomials

The operations on polynomials in algebra have their counterparts in the operations on integers in arithmetic. This is an instance of the mutual reinforcement of two subject matters. Arithmetic can be used to show the reasonableness of the algebraic procedures while the algebraic treatment can be utilized to reveal some of the inner workings of arithemtic that may not have been perceived previously. There is a good opportunity, too, to acquire a better understanding of our number system, based on ten, and to attain a general notion of a number system based on other integers. This can be considered as a contribution to a liberal education, for the mind is freed from the fixed idea that there is only one true number system. One way to approach the meaning of a polynomial is to compare $3t+5u$ and 35. The latter means and is equivalent to $3\times10+5$. The meaning of $2n^2+4n+5$ can be related to the meaning of 245 which is equivalent to $2\times10^2+4\times10+5$. If the number base is 5 or 12 the meaning and value of 123 (in this case, not one hundred twenty-three) will be $1\times5^2+2\times5+3$, namely, 34, or $1\times12^1+2\times12+3$, namely, 169. One of the authors has seen the idea of different number systems taught successfully in grade 7 and therefore is convinced that the concept is not too difficult for ninth grade students.

Addition and subtraction. With these ideas in mind it is fairly easy to show the relationship betweeen the sum and difference of 342 and 127 and that of $3h+4t+2u$ and $h+2t+7u$. Of course, the same ideas

can be developed by using line segments of different length for each of the three letters.

Multiplication and division. A comparison of the two problems below can lead to the following understandings:

12	$t+2$
$\times$ 32	$3t+2$
24	$3t^2+6t$
36	$2t+4$
384	$3t^2+8t+4$

1. The addend which is apparently 36 is really 360 since it is the sum of 3 hundreds ($10^2=100$) and 6 tens. Hence, in the future instead of indenting the partial products, zeros should be used where they are appropriate.
2. If $t+2$ had been multiplied by 2 first instead of by $3t$, the final result would not have been changed. Likewise, it is possible to multiply 12 by the 3 first and still obtain 384 as the sum respectively of 360 and 24.

The division of $3t^2+8t+4$ by $t+2$ can, in a similar way, be compared with the division of 384 by 12. Again, the indenting of the partial products can be rationalized.

The multiplication of polynomials can also be pictured as the problem of finding the area of a rectangle when its two sides are known. This can be seen in the figure at the left above. In the case of division the analysis is probably too difficult and confusing. The proof of division can also be used to show that division is the operation inverse to multiplication.

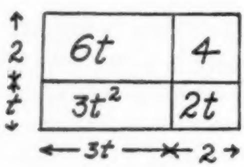

FIG. 1

By cutting out the partial products with a scissors the student can perform one of the "overt acts" with sense materials mentioned earlier. It is doubtful that the accretion to meaning resulting from this activity would be considerable, however, since the drawing itself reveals the essential relationships. This observation is in agreement with psychologist McConnell's remark that "learning is essentially complete when the individual has clearly perceived the essential relationships in the situation. . . . "(4).

DIRECTED NUMBERS

Algebra textbooks and writers on the methods of teaching mathematics have given such extended treatment to this topic that it would be verging on redundancy to treat this subject fully. The treatment by Everett (5) comes close to what the authors would do in teaching directed numbers. Hence, the remarks here will bear only on developing the meaning of the multiplication of positive and negative numbers.

In the accompanying figure assume that the product of $+5$ and $+4$ has been taught. Let AB move to the left keeping parallel to itself and to OC, to which it was originally parallel. The area of the rectangle $OABC$ will decrease from 20 to 15, 10, 5 and 0 successively.

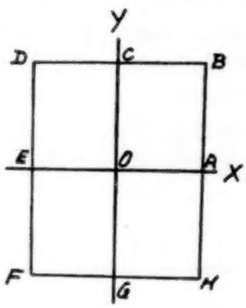

FIG. 2

Intuition will dictate that when AB is one unit to the left of OC the area of the rectangle will be -4 from which it will decrease to -10, -15 and -20. Now let DC move downward assuming the values -20, -15, -10, -5 and 0. After crossing OE, then, it should take on the values, $+4$, $+8$ etc. to $+20$. Hence, it is reasonable to conclude that the product of two negative numbers is a positive number. By letting FE travel to the right, negative results will be obtained in the fourth quadrant. The generalization about the product of two numbers with different signs is now apparent.

Another way of showing the reasonableness of the product of two negative quantities is as follows (6):

Assume again, that the product of $(+35)$ and $(+2)$ is known to be $+70$. Since $+2=+7-5$, $+3(7-5)=+6$. Hence, $(+3)(+7)+(+3)(-5)=+6$ or $21?=+6$. Therefore, the question mark is -15. Hence, $(+3)(-5)=-15$. Now let $3=7-4$. Then, $(-5)(+7-4)=-35+?=15$. Therefore, the ? is $+20$. Hence, -5 times -4 equals $+20$.

A third procedure is to use a story like the following: Two persons enter a town $(+2)$, but they have no money and the town has to spend \$3 on each (-3). The town is thus \$6 poorer (-6). The two persons move out of the town (-2), and the town's expenditures decrease by \$3 per person (-3). The town is \$6 better off $(+6)$ or $(-2)(-3)=+6$.

EQUATIONS

The analogy of an equation to a balance and the notion of solving an equation by using operations inverse to those in the equation itself are two ideas used in teaching a meaningful solution. These are too well known to call for more attention.

Another idea that contributes to the understanding of the equation is that it is a symbolic statement asking a question about numbers in contrast with the identity which makes a statement. For example, the equation, $5b+3=18$ asks "what number multiplied by 5 and the result increased by 3 gives 18? or, "Is there a number which satisfies this relation?" On the other hand, the identity, $4c+3c=7c$, states that the sum of 4 times any number and 3 times the same number always equals 7 times that number.

Line segments can be used to illustrate the solution of an equation. Figure 3 represents the equation, $3a+2=a+8$. A study of the diagram reveals that $2a=6$ and, therefore, $a=3$.

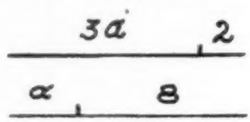

FIG. 3

Another way of enriching the meaning of an equation is to use a graphic approach. Consider the equation, $2d+3=7$. With d as an independent variable graph the function, $2d+3$, as in Figure 4. The value of d corresponding to the function value of 7 is the root of the equation. This is seen to be 2.

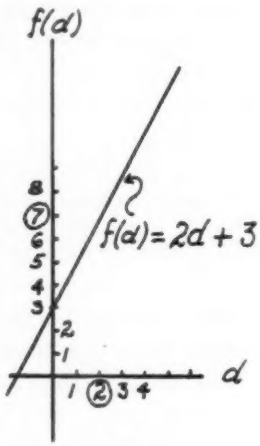

FIG. 4

This same graphic method can be used as background for the solution of a pair of linear equations graphically. For instance, the solution of the above equation can be considered as the intersection of the graph of the left member of the equation, $2d+3$, with the right member, $f(d)=7$. Of course, it is not necessary that the right member be a constant. On the contrary, the solution of any linear equation,

$ax+b=cx+d$, can be considered as the intersection of the graphs of $f_1(x)=ax+b$ and $f_2(x)=cx+d$. The fact that the two straight lines never meet again if they meet once is usually a very convincing argument in problem solving that only one solution is possible.

When pairs of linear equations are first solved by graphic means, it is probably better to solve them first explicitly before tabling the values of the function and the independent variable. If this is done, it seems more logical to the student to introduce next the solution of the linear pairs by the method of substitution. For instance, in solving the pair $2x+3y=8$ and $3x-y=1$ it is probably better to obtain $y=(8-2x/3)$ for the first and $y=3x-1$ for the second before constructing the table of values. After experience with this graphic approach, it is relatively easy to introduce the method of substitution. The method of addition and subtraction does not seem in the same logical sequence but, on the contrary, is more closely related to the axiomatic technique.

Quadratic Equations

The solution of the general quadratic equation, $ax^2+bx+c=0$, by completing the square can be demonstrated geometrically as well as algebraically (7). The figure at the left can be used for the solution of $x^2+2x=8$. The square represents x^2. The $2x$ is represented by the sum of the four equal rectangles bordering the square. Completing the square can be seen to mean adding a small square at each of the four corners so as to make an enlarged square. The altitude of each of the four rectanlges is $\frac{1}{4}$ of 2, or $\frac{1}{2}$, while the area of each one is $\frac{1}{2}x$.

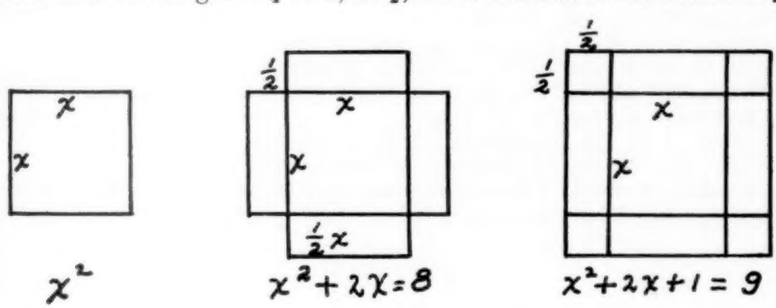

Fig. 5

The area of each of the four small squares needed to complete the square, x^2, is $\frac{1}{4}$. Hence, 1 must be added to complete the square. Therefore $x^2+2x+1=9$, or $(x+1)^2=9$. Therefore, $x+1=\pm 3$. The rest of the solution is obvious. When the coefficient of x^2 is not 1, but a, it is better to divide both sides of the equation through by a before resorting to the diagrams, although it would be possible to use the square root of ax^2 as the side of the starting square.

Proofs in Algebra

The proof concept is one that should be given careful attention throughout all the mathematics of the elementary and secondary school. Proving answers in arithmetic, the use of estimates and the checking of solutions in algebra are some of the cases where proof is given emphasis. Simple deductive proofs of certain of the simple properties of integers can be given after common monomial factoring and the difference of two squares has been learned. The meaning of algebra as a system for proving generalizations is thus demonstrated and an introduction to the importance of careful definition can be made obvious. For example, to prove that the sum of two odd integers is always equal to an even integer, let n be an integer and let an even integer be defined as any integer exactly divisible by 2. Let k also be an integer. Then $2n+1$ and $2k+1$ represent any two odd integers. The sum of these is $2n+2k+2$, into which 2 divides $n+k+1$ times. Since n and k are integers, 2 is an exact divisor of $2n+2k+2$, which is, therefore, by definition, an even integer.

Conclusion

It is realized that the above illustrations of attempts to put more meaning into algebra by no means exhaust the possibilities. It is the hope of the authors that others will publicize their favorite ways of having algebra make more sense to learners.

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TURTLE AND FISH FOSSILS DUG UP FROM WYOMING PLAINS

Fossil bones of sea creatures of 100,000,000 years ago were dug up in the West during the past summer and have been brought back to the Smithsonian Institution here by Dr. D. H. Dunkle. Among them are the skull and jaws of a big sea turtle and the bones of several large fish that may have been distant cousins of today's tarpons.

These animals inhabited an ancient sea that stretched from Alaska to the Gulf of Mexico during Cretaceous time. Silts and sands of the old sea bottom, containing the bones dropped there when the animals died, have hardened into stone and been slowly raised to their present level, far from any ocean.

THE ENIGMA OF THE FLOWERING PLANTS

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The flowering plants are often called Angiosperms because of the seedcases or ovaries (aggeion) that enclose the sperms or seeds. Botanists have described some 155,000 species of flowering plants and many new plants are added to this list each year. About three fourths (115,000) of the species belong to the class called Dicotyledons because of their two seed leaves. The other fourth (40,000) belong to the class Monocotyledons that have only a single seed leaf. These classes are again divided into 51 orders, 275 families and more than 6,000 genera.

The above numbers, however, apply to the Angiosperms of the whole world. If we limit our study to the plants found in a smaller area, we find numbers that are comprehensible. Pepoon states that in North America, north of Mexico, there are 195 families and 16,253 species.

	Orders	Families	Genera	Species Total	Monocots
Britton & Brown, N.U.S. & Can.	42	181	1188	4508	1261
Gray (7th Ed.) N.E. U.S.	40	144	960	3936	1085
(Introduced 666 species)					
Rydberg, Prairies and Plains		165	1329	3868	936
Jepson, California		143		3892	778
(292 aliens and 1416 endemic)					
Jones, Illinois	37	138	680	2050	576
Pepoon, Chicago Area	38	138	670	1841	503

The Chicago Area, because it includes parts of three great life zones, Canadian, Transition and Upper Austral, and because of its great number of habitats, forests, prairie, river, lake, marsh and duneland, is noted for the great number of species found in a small area.

A natural system of classification attempts to arrange the Angiosperms in order of kinship. Information comes from various sciences, among which are morphology, physiology, ecology, biometry, paleontology and genetics.

According to the theory of evolution, there should be a structural advance from simple and generalized to complex and specialized forms. So varied are the modes of development that no single "consecutive sequence" has been discovered that will indicate this relationship. In general, close kinship due to common origin is marked by strong structural similarity. However, convergent evolution, the fact that many plants such as the xerophytes living under similar conditions may resemble each other, plays an important part with the result that homologies become more important than analogies.

A group may be advanced in some respects but primitive in others as the hypogynous mints, the polypetalous orchids, the dioecious clematis and the syncarpous water lilies.

In 1775, Linnaeus based his classes and orders upon the number and position of the stamens since these are among the more stable structures. In 1789, Antoine de Jussiue published the first classification of genera under natural orders. Asa Gray in 1858, noted that "we use an artificial classification only in the form of tables or an ılyse as a key to finding out the family to which a plant belongs." Engler and Prantl's "The Natural Plant Families" published at Leipzig in 1889 and the English writers, Bentham and Hooker, after separating the subclasses divide each into the primitive Apopetalae which are without petals or with separate petals and the Gamopetalae with united petals. Sometimes the Apopetalae are divided into Apetalae and Polypetalae.

A typical flower is pentaclinic, that is, it has five cycles of parts, a calyx and corolla, an androecium usually of two cycles or whorls of stamens and a gynoecium of one or more pistils. Advancement in morphology consists of reduction or elimination, combination or adnation and elevation of these parts.

Reduction in number of parts of a series is from many and indefinite to few and definite. Their attachment changes from elongated spirals resembling the common arrangement of leaves on stems to concentric circles or whorls and from pentacyclic to tetracyclic flowers through loss of one set of stamens. Ray-like actinomorphic flowers change to bilaterally symmetrical zygomorphic and asymmetrical flowers. Flowers change from two-sexed to monoecious where staminate and pistillate flowers are both on the same plant, then to dioecious where the sexes are separated. Further reductions include the lack of perianth in anemophilous flowers, the pappus and scales of the composites and vestigial organs such as staminodes, setae and lodicules.

Combinations of pistils to form compound ovaries lead to the elimination of carpels so that the higher groups are bicarpellate and produce only a single seed. The petals and sepals change from apopetalous to gamopetalous and the stamens from polydelphous or branching to columnar or diadelphous and finally to monadelphous. In the insect pollinated flowers, there is a general elevation of the perianth and androecium so that the gynoecium becomes half-inferior or inferior and the petals and stamens become inserted upon the calyx tube or the stamens upon the corolla tube.

Embryology is concerned with the character of the pollen tube and the pollen; the number of cells of the anther and their method of opening; the production of gametophytes and gametes and the nature

of fertilization; the number of carpels and ovules; the attachment of the ovules and their position within the carpels; the position of the embryo; the presence of perisperm and endosperm; the number of seed coats and the growth of the embryo and the method of germination.

Characteristics of less importance are the inflorescence whether solitary, corymbose or cymose, the presence of bracts and the dorsiventrality, or relation of the median plane of the flower to the plane of symmetry; the duration; plant geography and distribution together with ecology, the habitat and special feeding habits; comparative morphology of the vegetative organs such as the shape, venation and phyllotaxy of the leaves, the habit, the character of the stem; the aestivation or vernation; the growth and structure of the roots and the character of the fruit. Plant proteins act as antigens which may be used to some extent in tracing relationships. Secretions may be aromatic, acrid, colored, milky, oily or mucilaginous.

One of the most disconcerting factors in classification is the elimination of parts found in some groups. It now appears that the Monocotyledons were derived from the Dicotyledons and so they are probably a more advanced group. The presence of lodicules, the vestigial corollas in the flowers of the grasses and of epiblasts the vestigial cotyledons in their seeds, are two lines of evidence. The polycarpous gynoecia of the pondweeds, arrow-grass and water plantains and the spiral arrangement of the stamens in the arrow-heads are connecting links between the two groups.

Unfortunately as to evidence from Paleontology, most flowering plants live in dry areas where they are unlikely to form fossils. The earliest Angiosperms such as the sassafrass and magnolia originated in the late Mesozoic Era or the Cretaceous, about a hundred million years ago. According to Coulter, the great development of modern annual, herbaceous plants probably came much later in Cenozoic times after the establishment of a winter season in the north. Flowering plants are most closely connected with the Bennettitales (Cycadeoida superba) a group of extinct cycad-like plants found in the Dakotas. These ancestral plants had fruiting bodies containing central clusters of stalked megasporophylls surrounded by pinnate microsporophylls. Below these were many hairy, sterile bracts resembling a perianth. A seed, containing a dicotyledonous embryo with little endosperm was produced by each of the hermaphroditic flowers. Like all cycads, their pollen produced motile sperms. The conifers seem to have separated from the Corditales, another group of extinct cycads, long before this in Paleozoic times.

The flowers and fruits of the simpler Polycarpiceae or Ranales such as the marsh marigold, anemone and magnolia, most closely re-

semble the ancestral cycads. The floral organs are numerous, separate from each other, arranged spirally and the fruits are generally achenes. Charles E. Bessey in 1914 worked out a classification based upon these apocarpous forms as the simplest flowering plants. Other workers in this field were Robertson, Hallier, Lotsy and F. Sargent.

According to the Bessenian System, the rest of the Angiosperms fall into three great groups or subclasses showing parallel development, the pentamerous, hypogynous Malveae, the perigynous or epigynous Roseae and the trimerous Lileae. According to Clements and Showalter 1927, each of these groups is divided into two major series, one of which ends in a zygomorphic, entomophilous family and the other in a diclinic, anemophilous family. The mallows become mints and goosefoots, the roses asters and walnuts, and the lilies orchids and grasses. Even the Asters have their diclinic group, the ragweeds. The anemophilous plants, the goosefoots, ragweeds, walnuts and grasses, have become dominant, at least in temperate climates. Each has dioecious bisexual flowers that produce single seeds. There are, however, numerous exceptions such as the trimerous pawpaws, moonseeds and barberies among the buttercups, the trimerous Polygonales and the tetramerous Piperales among the mallows and the dimerous Fagales among the roses. In these and similar discrepancies lies the enigma of the flowering plants.

The latest methods of determining relationship are furnished by Cytology and Genetics through the study of the number, structure and behavior of the chromosomes, the location of the genes and the nature of hybridization, mutation and inheritance. In study of economic plants such as the grains, it is found that the chromosomes in the body cells are constant in numbers and in characteristics. This diploid number varies from six in hawk's beard to 114 in marsh mallow. Chromosomes are of some value in tracing ancestry for those within a genus are often multiples of some simple number. Wheat has polyploid numbers 14, 28, and 42, all multiples of seven. Oats, also, has the same numbers. Barley has 14, corn 20, sorghum 10, 20 and 40, rice 12 and 24; cotton 13, 26, and 52; lilies have 12, 24, 36 and 72; roses 14, 21, 28, 35, 42, 49 and 56. But all are not so simple as this. For instance flax has a chromosome number of 30 while other species of the same genus have such irrational numbers as 16, 18, 20, 28 and 36. Red clover has a diploid number of 16, while other legumes have 12, 13, 14, 16, 18, 20, 24 and 40. Sometimes, plants with the same number of chromosomes, even if distantly related, will cross but the seeds are infertile. Mutations, caused by the loss or gain of genes, may occur in both the reproductive and vegetative parts of a plant. Branch bud sports occur spontaneously in some groups as the primroses and wall flowers. The production of mutations by treatment

of the plant with radiant energy or by the use of colchicine is not uncommon in plant genetics.

While the cells of many species have the same number of chromosomes, they must differ qualitatively. Since no correspondence has been discovered between the number of chromosomes and the broader classification of plants, many botanists believe that the true relationship will become evident only after the character of the complex chemical groups, called genes, has been discovered.

THE AFTERMATH

(A classroom game)

SISTER AGNES
Notre Dame High School, Chicago

I. Prefix, insert, or add *one* letter to change each of the following words to a "Math-word." Do not change the sequence of the letters as they occur in the original word:

1 ad	....	15. cope	....
2. are	....	16. cure	....
3. sin	....	17. sole	....
4. cub	....	18. prim	....
5. rot	....	19. sale	....
6. mat	....	20. sold	....
7. for	....	21. rang	....
8. axe	....	22. side	....
9. sew	....	23. suds	....
10. cord	....	24. eight	....
11. plan	....	25. actor	....
12. pint	....	26. enter	....
13. able	....	27. scant	....
14. cute	....	28. unction	....

II. Substitute *one* letter for *another* without changing the sequence of the letters remaining in the word:

1. national	....	15. role	....
2. cheek	....	16. sinus	....
3. tower	....	17. hearing	....
4. grape	....	18. hero	....
5. corn	....	19. lector	....
6. nest	....	20. hum	....
7. sight	....	21. are	....
8. germ	....	22. knit	....
9. puss	....	23. bass	....
10. egg	....	24. elope	....
11. light	....	25. grove	....
12. patio	....	26. way	....
13. lane	....	27. court	....
14. steed	....	28. lock	....

III. Prefix a syllable (or group of letters):

1. face	....	12. art	....

2. is	....	13. scribe	....
3. fine	....	14. action	....
4. sector	....	15. cent	....
5. tractor	....	16. amid	....
6. stem	....	17. ant	....
7. pass	....	18. bus	....
8. tangle	....	19. tend	....
9. here	....	20. vision	....
10. traction	....	21. cave	....
11. vex	....	22. portion	....

"THE AFTERMATH"
(Key)

I.
1. add
2. area
3. sine or sign
4. cube
5. root
6. math
7. form
8. axes
9. skew
10. chord
11. plane
12. point
13. table
14. acute
15. scope
16. curve
17. solve
18. prime or prism
19. scale
20. solid
21. range
22. slide
23. surds
24. height or weight
25. factor
26. center
27. secant
28. function

II.
1. rational
2. check
3. power
4. graph
5. cone
6. test
7. right or eight
8. term
9. plus
10. leg
11. eight or right
12. ratio
13. lune or line
14. speed
15. rule
16. minus
17. bearing
18. zero
19. sector
20. sum
21. arc
22. unit
23. base
24. slope
25. prove
26. ray
27. count
28. loci

III.
1. surface
2. axis
3. define
4. bisector
5. protractor
6. system
7. compass
8. rectangle
9. sphere
10. subtraction
11. convex
12. chart
13. inscribe
14. fraction
15. per cent
16. pyramid
17. slant
18. rhombus
19. subtend
20. division
21. concave
22. proportion

THE 1949 PACIFIC CHEMICAL EXPOSITION

"The date for the second Pacific Chemical Exposition by the California Section of the American Chemical Society for 1949 has been set for November 1 through 5 at the San Francisco Civic Auditorium," says Marcus W. Hinson, manager.

The floor plan for the '49 Show is scheduled to be in the hands of former exhibitors on the morning of January 3, 1949. "These former exhibitors will have about two weeks in which to select their space before it is thrown open to others," says Mr. Hinson.

"As in 1947, the Pacific Industrial Conference will run concurrently with the Pacific Chemical Exposition. These one- and two-day conferences of the twelve cooperating national and local societies and associations provided one of the most outstanding over-all conference programs ever given in the West," says Mr. Hinson, and it is expected that an even finer program will be assembled for 1949.

THE EXTENT OF CONSERVATION EDUCATION IN THE SECONDARY SCHOOLS OF INDIANA[1]

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INTRODUCTION

In order to determine how extensively the conservation of natural resources is taught in the secondary schools, a questionnaire was prepared last spring and distributed to a sampling of two hundred Indiana high schools. Questions, included general information on teacher qualifications, what aspects of conservation are included in separate subjects, extra-curricular opportunities, community assets, and available laboratory, field and visual aids for studying the conservation of local resources. The questions were so designed as to apply to all schools in both the rural and urban centers.

The distribution of the questionnaire was based on five population categories as follows:

Group I —Towns of 1,000 population or less
Group II —Towns over 1,000 to 2,500 population
Group III—Cities over 2,500 to 5,000 population
Group IV—Cities over 5,000 to 10,000 population
Group V —Cities over 10,000 population

For purposes of greater accuracy in sampling, forty per cent of the questionnaires were sent to schools in Group I, thirty per cent to Group II, and ten per cent to each of Groups III, IV, and V. These were sent personally addressed to each high school principal with a self addressed return envelope enclosed. Sixty per cent, or 120 of the questionnaires were returned within the time limit decided upon. With the population and random sampling method used, eighty-five per cent of the counties of the state were covered and of these only fifteen per cent failed to respond.

In addition to finding how widespread conservation education is practised in the high schools, it is hoped that the data will serve to offer suggestions and advice to form a closer cooperation between the schools and local and state conservation agencies. The Indiana Department of Conservation, the Extension Service of the State Agricultural College, the state Soil Conservation Service, and others are willing to offer many aids to the schools when called upon. Moreover, the results may help stimulate and encourage keener interest in the teaching of conservation of natural resources.

[1] Based upon a paper prepared by Robert G. Hitt, Department of Forestry, Purdue University, as a special credit assignment, 1948.

Evaluation

Replies to the questions as indicated revealed some interesting results. The largest percentage of schools employing teachers with temporary permits were those in groups I and II. The range here varied from thirty-four per cent with one permit teacher to six per cent with five permit teachers.

The number of permit teachers found in the schools of each of the groups sampled was as follows: three out of four in Group I; two out of three in Group II; one out of four in Group III; one out of five in Group IV; and one out of ten in Group V. The percentages of schools having one or more teachers with advanced degrees varied from ten per cent in Group I to one hundred per cent in Group V.

In the smaller groups generally, as represented in the first two groups, the qualifications of teachers are obviously neither as high nor as specific for the subjects taught. A teacher in these schools frequently has more courses to teach that are as divergent as typing and physical education than do teachers of the larger schools. This reduces the effectiveness of teaching science and conservation, if taught at all, and especially deprives the rural student who is closest to the land, of practical conservation knowledge.

In the section that listed separate conservation topics the following were included: (1) conservation history and laws, (2) soil erosion and control, (3) flood control, (4) stream pollution, (5) land drainage and its problems, (6) proper land use through rotations, fertility, etc., (7) forest conservation, (8) wildlife conservation and, (9) forest products, their use and importance. The schools were asked to indicate in what high school subjects each of the topics were taught.

The courses that were listed most frequently as teaching the suggested conservation problems were given in the following order of emphasis: biology, agriculture, social science, general science, and geography. A more limited amount was taught in civics, history and economics. Very few of the larger systems offered courses in agriculture, but this area for teaching conservation was more than compensated for by the excellent teaching possibilities in biology, zoology, botany and chemistry. A few of the larger schools indicated a separate course in conservation.

In health and safety education, which are required state courses, the only conservation topics that were taught were stream pollution and flood control. Source of water supply, effect of drainage on malarial control, insect borne diseases, relation of diet to soil fertility and other problems are obviously not thought about from the conservationist's viewpoint in these prescribed courses.

Among extra-curricular activities that afforded opportunity for teaching conservation the 4-H club was most often listed. It was the

most common high school club in the smaller schools as should be expected. Next in importance were the science clubs which were naturally found chiefly in the high schools in cities over 10,000 population. Nearly all chapters of the Indiana Junior Academy of Science were found in the latter category.

Greater science club activity in the larger centers can be attributed to the availability of better scientific equipment, more specific science training of teachers and possibly greater scientific interest due to urban industrialization. However, present day mechanized agricultural operations would definitely assume the need for greater scientific activity among rural youth populations.

An extremely low percentage of small community schools signified any development of Outing clubs, Nature societies, and Audubon clubs. Though it would seem that such clubs are less essential to farm children who live closer to nature, there is all the more need for developing conservation attitudes and an appreciation for the out-of-doors. In this age of machine-farming our farm people should be encouraged to make greater use of their local streams, woods, and fields for enjoyment and relaxation instead of attempting to find entertainment of dubious value in the cities.

The relation between teaching conservation and actual school participation in conservation practices was worthy of note. Thirty-two per cent of the schools in Groups I and II said they took part in erosion control work. The same percentage taught erosion control in biology and nearly sixty per cent taught it in agriculture. In the other groups, more than fifty per cent of the schools showed that erosion control was taught in biology and agriculture while less than fifteen per cent practised erosion control measures. This points a special need to correlate more closely classroom and outdoor field work. To be effective, classroom procedure should be stimulated and supplemented with actual outdoor practices in the form of laboratory periods, or excursions to nearby areas.

Few schools maintain bird sanctuaries, winter feeding stations, or conduct bird and mammal censuses. Such activities improve the knowledge of students and, if accurately done, may contribute valuable scientific records to conservation and science of the state.

A list of local assets to conservation education was suggested and each school was to check those available to the school and also those of which the school made active use. Forty-three per cent of the counties of the state are wholly orpart ially organized into Soil Conservation Districts. Our survey covered ninety per cent of these counties. Twenty-five per cent failed to respond, but of the remainder, all did have Soil Conservation Districts. According to their replies, only sixty-four per cent listed the Soil Conservation District as a local available

asset and only forty-seven per cent of those listed were used. Group V led with one hundred per cent of the schools indicating that Soil Conservation Districts were available and seventy-five per cent used, while only fifty per cent of Group III listed them as available and thirty-three per cent used.

Sixty to sixty-five per cent of the schools in Groups I, II, and IV checked the Soil Conservation Service as being available and thirty to sixty per cent used. Unfortunately, the schools in Groups I, II, and III, which most need the service of the Soil Conservation Service, are not all aware of its existence and do not take advantage of this important community asset.

In the case of the Extension Foresters, it happened that questionnaires were sent to two of the four home localities of these men. One of the schools, presumably did not know about the forester's office since there was no indication as to his availability. In the other reply, the school recognized the presence of the Extension Forester, but his services were not used.

Ten questionnaires were sent to towns where District Foresters worked. Half of the schools in these communities did not recognize the availability of the forester while the other half checked that he was available but did not use his services in the school.

An average of eighty-eight per cent of the replies recognized the County Agricultural Agent as available for lectures, demonstrations and the like and sixty-eight per cent said he was used in the schools. Other community assets that were named included the Boy Scouts, the AAA, Game Wardens, State Forester, Chambers of Commerce, Newspapers, Isaak Walton League Chapters, and the Indiana Department of Conservation.

Obviously, a better program of conservation education could be achieved if schools were more fully aware of local conservation agencies and other community assets. Teachers and school administrators should acknowledge the value of trained specialists in conservation and should make an effort to include their services to develop a well rounded program of conservation education in the schools.

City and community parks were indicated as available to all groups and were effectively used. Ninety-two per cent of the schools in Group V reported that municipal parks were available and sixty-four per cent of the schools used them. The other groups followed with lower percentages of availability and use. The smaller schools reported greater use of State Parks and State Forests. The problem of transportation is most likely the reason for this. In rural areas, school buses are used to visit parks, while city schools must use private cars or charter buses for transportation. Thus, for city schools, the cost is greater for either the students or the school and becomes

a limiting factor for visiting state parks and forests. Also, most of the state parks and forests are in rural areas making them more readily accessible to rural children.

Schools in their use of city and county parks or state forests and parks probably do not use them in the strictest terms of conservation education. Most schools use them for commencement picnics, or social and recreational outings. While this phase of outdoor use is important, why not use them as outdoor classrooms also? There is no better means of teaching conservation than to observe and study forests and wildlife as they exist naturally.

About one third of the schools reported access to state game preserves and half of these stated that they were used. Industrial plants, sewage disposal plants, lumbering operations, and strip coal mines were checked as available and used by many schools. The importance of actually witnessing these community activities cannot be overemphasized as a real teaching aid.

The schools in all the groups seemed reasonably well equipped with regards to general instructional aids. If any particular teaching aid was lacking it was compensated for by the use of another. For example, very few of the smaller schools listed greenhouse facilities, although they made use of garden plots. A larger number of the city schools reported greenhouse facilities with fewer garden plots available for study.

Most schools in all groups listed microscopes, lantern slides and projectors, moving picture films, projectors and screens, and charts as available for the study of conservation. Items, like mounting boxes, leaf collections, animal skins and herbaria were more common in the larger schools.

The schools in smaller communities in most cases had a better percentage of availability of outdoor tools, soil testing kits, and the like, but this is understandable because of their greater need for these in connection with the course work in agriculture and soils.

Summary

The overall picture of the teaching of the conservation of natural resources in the state is encouraging. An honest attempt based upon the present training and knowledge of teachers is being made to develop proper conservation attitudes. There is, however, much need for improvement and expansion.

Results obtained show that teachers of biology and agriculture are devoting more attention to conservation than others. Chemistry is rarely recognized as being important in this connection, yet many of the needs of chemistry are dependent upon natural resources and so much of the production of renewable resources depends upon a knowl-

edge of chemistry. The chemistry course could emphasize the importance of fertilization upon crop production and soil maintenance. Much of our modern wisdom in utilization of farm and forest products stems from the chemical laboratory.

There is an apparent need for raising the standards, qualifications and teaching assignments for teachers of science in the smaller community high schools. Teachers should be given the opportunity to satisfy these requirements and should not be expected to do an effective job in totally unfamiliar subjects for which they have had neither training nor experience.

A cooperative school-community attitude should be developed for teaching conservation. The activities of the school and community should be so correlated as to work hand-in-hand on problems of conservation. Soil conservation demonstrations, tree planting programs, wildlife habitat restoration projects, and stream pollution abatement, sponsored by civic and other local conservation agencies can be attended by school groups and they should be given some responsibility to help in the work. Development of county and municipal parks, streamside beautification, roadside landscaping and other local projects can be worked out to give invaluable assistance in cultivating a community conservation consciousness, not only in the schools but among the general public as well.

Conservation education should be better integrated throughout the entire high school science program. It can and should become a part of the entire high school curriculum. The present study shows that only a few specific areas in the secondary schools give adequate attention to the teaching of conservation. An honest and sincere effort to stimulate and correlate classroom discussion with outdoor field experience or problems must also be achieved.

The school clubs and extra-curricular activities should be made to play an important part in the conservation program. In these activities the actual practice should augment the classroom discussion. The students, with proper guidance, would develop an awareness of the need for conserving natural resources and an appreciation of its importance to the community and the nation.

Finally, school administrators and teachers must recognize and use available conservation offices and agencies in the school program for the teaching of the conservation of our natural resources.

Water-injector, to add moisture to gasoline entering automobile engines, utilizes the dual fuel principle employed on some airplanes. This easily installed unit is controlled through connection with the accelerator; as the gasoline feed is increased, the supply of water injected into the carburetor automatically increases.

ALTERNATING CURRENT MOTORS IN HIGH SCHOOL PHYSICS

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Interest in the advisability of treating the subject of alternating-current motors in an elementary course in physics comes from an experience of the spring of 1943. In that year the last two lessons in current electricity were cancelled when the school participated in war activities. These two lessons contained: 1. impedance, reactance, lag and lead of current in inductive and capacitative circuits, and power factor. 2. rotating magnetic field, alternating-current motors of two and three phases, squirrel-cage rotor, shaded-pole motor, and series motor. Since we were of the opinion that these topics could not be skipped without serious loss of completeness of subject-matter, that the terminal lessons have as much importance as the initial ones and cannot be skipped with impunity, and besides, wishing to investigate whether student interest held to the bitter end, we offered these lessons after school hours on an extra-curricular basis. No praise or blame was attached to attendance or absence. The student response both in attendance and enthusiasm was overwhelming. A veritable barrage of questions "mowed the teacher down," questions which extended the time far beyond what had been intended. The

ALTERNATING CURRENT MOTORS IN HIGH SCHOOL PHYSICS TEXTS

Authors, Copyright Date	Lines	Length in cm.	Photographs	Diagrams	Questions
Black & Davis* 1938	68	10.3	Induction Motor Elihu Thomson	Two-phase a.c. Rotating magnetic field	5
Bower & Robinson 1942	104	10.0	D.c. to a.c. Demonstration	Two-phase a.c. Rotating magnetic field	3
Burns, Verwiebe, Hazel 1943	26	12.2	(none)	Whirling magnet Rotating magnetic field	3
Duff & Weed 1928	20		(none)	(none)	4
Dull*† 1939	16	9.8	Induction Motor	Electric clock gears	(none)
Fuller, Brownlee, Baker* 1947	56	12.0 10.0	Induction Motor	Two cycles of three-phase voltage	2
Henderson* 1935	88	9.7	(none)	Two-phase a.c. Rotating magnetic field Squirrel-cage rotor	4
Holly & Lohr* 1939	3	10.0	(none)	(none)	(none)
Milliken, Gale, Coyle* 1936	59	10.0	Induction Motor	Two-phase a.c. Rotating magnetic field Three-phase circuit Squirrel-cage rotor	3
Sears 1922	25	8.3	(none)	(none)	(none)
Stewart, Cushing, Towne* 1932	57	9.5	Squirrel-cage Armature	Two-phase electromagnet Two-phase a.c.	3
Wilson 1936	48	9.8	Gramme Ring Coil	(none)	3
Whitman & Peck† 1946	104	12.0	(none)	A.c. motor in electric razor	(none)

* State approved texts.
† Adjusted for split pages.

conclusions reached were that students were intensely interested in the practical applications rather than in the theory, in non-technical, non-mathematical presentations, rather than in the strictly logical, scientific ones.

Validation

Doubts arose as to the legitimacy of such a procedure both as to content and to presentation, if the lessons were given during regular school periods. Investigation into the contents of ten textbooks approved by the state curriculum were somewhat indecisive; seven of the ten gave only small mention to alternating-current motors. But at the same time it was noticed that there was a definite trend in the newer texts and in the revisions of the older ones to include more lines, photographs, and diagrams. Investigation into fifteen other texts only confirmed the earlier findings. In the TABLE we see that the number of subject-matter lines shows quite a range (25–104), from a mere mention to some rather detailed descriptions. While the kinds of diagrams used are unvarying from one text to another, there is much diversity in photographic illustrations. All in all, it seems that thought on content of alternating-current motors has not crystallized.

Curricular Recommendations

We found in the Missouri Public School Curriculum,[1] SUBJECT MATTER OUTLINE "2. The alternating-current motor, a. The synchronous motor and the electric clock; b. The induction motor; c. The universal motor. 3. Characteristics of alternating-current circuits, a. Meaning of volt and ampere in alternating-current; b. Impedance compared with resistance; c. Three-phase systems; d. Power factor."

Teaching Procedure "1. At the high-school level, mathematical treatment of this subject should not be attempted. Try to make clear the essential nature of alternating-current and the important differences between direct-current and alternating-current principles. 6. Point out the special features of each type of motor, . . ."

Pupil Activity "There are not many alternating-current experiments that can be recommended for high-school laboratory work. . . . Study of the various household motors may be of value."

Provision for Individual Differences "The slower members of a class may be expected to learn the essential differences between direct and alternating-currents, that most power systems transmit the latter type, what is meant by 60-cycle current, and that it sometimes is necessary to specify the type of current available when ordering

[1] Natural Sciences Bulletin 6, 1941. *Missouri at Work on the Public School Curriculum, Secondary School Series*, Section V, Unit V, Magnetism and Electricity, page 476.

household electrical equipment. The better students may be interested in finding out why a shock from alternating-current line at 115 volts is more severe than one from direct-current line at the same rated voltage, why alternating-current generators are rated in KVA instead of kilowatts, what a three-phase system is, and why such systems are so commonly used."

Having arrived at satisfactory validation for the proposed lessons, it then becomes necessary to establish both their content and sequence, as also to implement the theory with appropriate demonstrations. Content being assured by survey of curricula, and sequence having been obtained from texts, there remains the necessity to

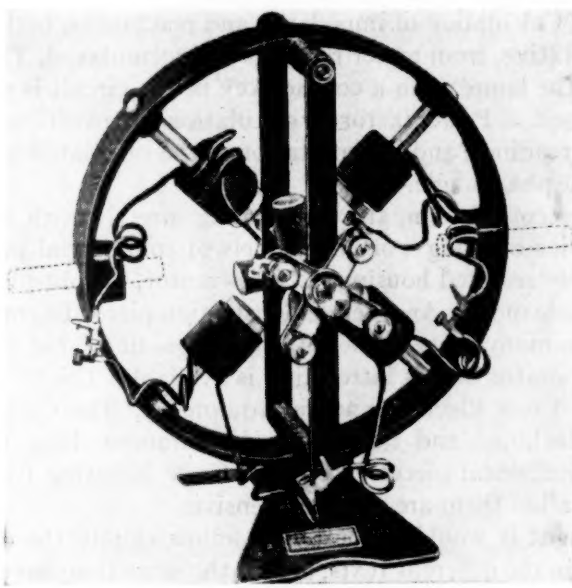

FIG. 1. Welch experimental motor.

revise the content of previous lessons so that there be no lacunae in theory lessons that lead up to the subject of alternating-current motors. For example, in the transformer principles are adequately taught, especially the phase relations between primary and secondary currents, and this demonstrated with the oscillograph, then much of the ground has been cleared for successful instruction of the shaded-pole motor.

DEMONSTRATIONS

It is self-evident that much of the success in teaching alternating-current motor theory rests squarely on many concepts contained in previous lessons, both in direct and alternating-current theory. It is

not the aim of the writer to detail such a list of necessary concepts as it can be found in texts and treatises on alternating-current motors.[2]

As so much of comprehension is founded on visual perception, adequate demonstration is imperative. Implimentation of lessons with adequate demonstrations depends on available equipment and on funds. When neither is sufficient, the ability to adapt existing apparatus to new uses becomes a necessity.

For the lesson preliminary to alternating-current motors the necessary demonstrations are well indicated in texts. a. Coil-lamp-ammeter in series to: 1. a. c. source; 2. d. c. source. b. Emphasis of choke effect by both meter reading and lamp brightness by: 1. changing the core length in the coil; 2. increasing the number of condenser sections. c. Calculation of impedance and reactances, both inductive and capacitative, from meter readings and formulas. d. The time lag as seen in the lamp when a contact key in the circuit is visibly and audibly closed. e. Power factor by calculation from volt-, ampere- and wattmeter readings, and interpretation of the calculated result as the cosine of the phase angle.

For the second lesson, the one dealing directly with motors, we have a choice of using working models of commercial motors each with severely resected housing: a. series motor, b. split-phase motor, c. shaded-pole motor. Another demonstration piece, diagrammed and explained in many texts, is the rotating magnetic field of a two-phase motor. Apparatus of this latter kind is available: The Evans Equipment,[3] The Crow Electro-dynamic Equipment,[4] The Crow Rotating Electric Machine,[5] and the Multipolar Gramme Ring Coil.[3,4] All these are horizontal pieces except the Crow Rotating Electric Machine, and all of them are rather expensive.

We thought it would be better to follow closely the diagram so often used in the different texts, and at the same time have a vertical piece rather than the more usual horizontal ones.[6] To operate our demonstration as a two-phase induction motor would require the production of two currents, 90° apart, from the one phase normally delivered. We could simulate two-phase currents by introducing a reactance into one branch of the single phase. Also, to make the demonstration still more interesting both a lagging and a leading current should be produced. Then resistive ballast[7] for one pair of field coils and reactive ballast for the other pair was needed.

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[2] Bishop, Calvin C., *Alternating Currents for Technical Students.* D. Van Nostrand Company, Inc. 1943.

[3] Cenco, Chicago.

[4] Milvay, Chicago.

[5] Universal Scientific Co., Vincennes, Indiana.

[6] Moody, F. W., "Induction Motor Demonstration," SCHOOL SCIENCE AND MATHEMATICS, 42: 489–490, May 1942.

[7] Ohmite, 100 ohm—100 watt resistor.

The cost of the apparatus could be kept down if we adapted the Welch[8] four-pole Experimental Motor, Figure 1, to alternating-current split-phase operation. Experimentally we found that a current of 1.00–1.25 amperes in each branch was necessary to rotate the four-pole armature to run as an induction motor when its commutator segments were shorted with copper wire. We took this current value as a standard. In practice this current does not unduly heat the coils even after an hour's demonstration. By introducing a s.p.d.t. switch in the reactive branch, Figure 2, it is possible to change quickly from inductive reactance[9] to a capacitative one.[10] This caused all our rotors to reverse direction immediately. The oscillograph patterns[11] obtained differ considerably from the classical Lissajou's figures. Student comprehension and acceptance of phase shift is difficult to

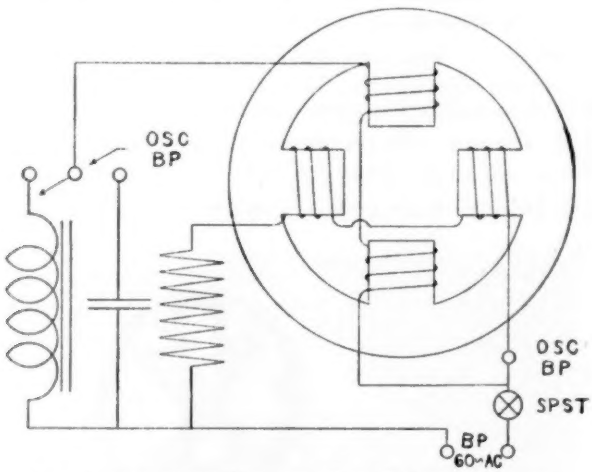


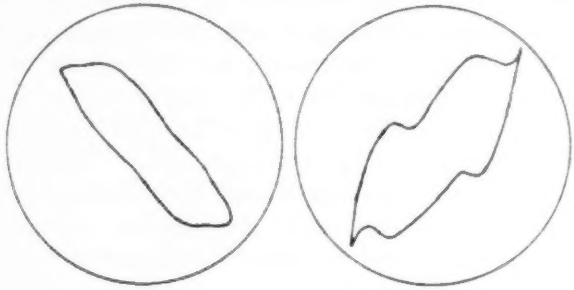
FIG. 2. Demonstration two-phase induction motor.

achieve at any time. Comprehension and conviction do come however, when the oscillograph pattern, distorted though it is, jumps from a 45° to 135° angle, Figure 3, at the same time that the rotor changes direction.

Rotors of various kinds were tried. The simplest was a single disc of iron (tin can top) on a wire axle with cone bearings; the four-pole d. c. armature (140 g.) with its commutator shorted with copper

[8] W. M. Welch Mfg. Co., Chicago. #2460B.
[9] G. E. fluorescent lamp ballast, #58G674 red and white leads tied together.
[10] Aerovox, 20 mfd., 220 v. oil filled condenser, RY 759.
[11] Oscillograph Settings (Dumont-Type 274).
Coarse Frequency at Hor. Input Amp.
Vertical Amp at 40; Horizontal Amp at 30.
Test Signal to Horizontal Input.
Test Probes to Vertical Input.
Vert. Input switch at Amp.
Some care must be taken for polarity.

wire; a commercial squirrel-cage rotor (220 g.) mounted on cone bearings; a six-legged spider made of twisted wires; a laminated d. c. armature, stripped of wire and commutator, cut into three radial sections 120° apart. All of these rotors were of the induction type.



a. Inductance. b. Capacitance.

FIG. 3. Oscillograph patterns.

The whole demonstration piece can be permanently mounted on a base (9×15). There is just no possibility to circumvent the physical size of ballasts, nor to get away from their cost. In mounting, we used red spaghetti tubing on the resistive circuit and yellow on the reactive

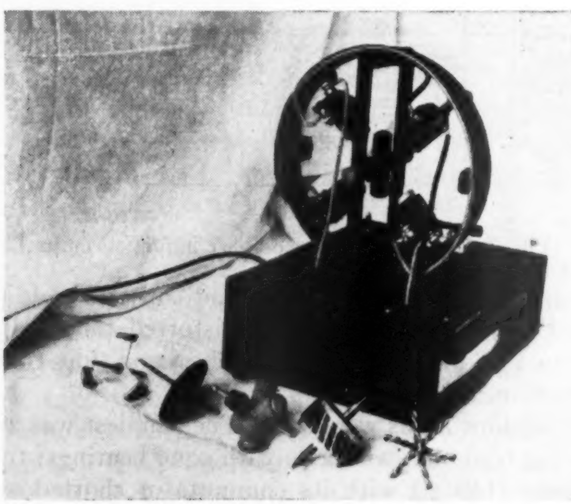


FIG. 4. Vertical rotating magnetic field.

circuit. We took liberties with the motor as furnished, to cut off the flexible connectors to the coils and replace them with binding posts mounted on added coil ends. We bent the wire connectors to the coil (in colored spaghetti tubing) conformal to the frame so as not to obstruct the view, but still be traceable, and to facilitate the change

of rotors. If it does not seem desirable to have the resistor and reactors visible, the base can be made much smaller by sub-chassis mountings.

The best recommendations for this modification, besides the fact of being a vertical piece and thus more visible, is that it runs. It reverses the direction of rotation of the rotor when switched from inductance to capacitance, and it is of reasonable cost.

The Laboratory Period

Laboratories having experimental motors, either the St. Louis Motor[12] or the Genemotor,[13] can impliment their direct-current equipment with an alternating-current armature with slip rings. Where there is no provision for alternating-current of low voltage in the school, a filament transformer, 10 volts, 5–8 amperes, can remedy this deficiency. Such transformers individually mounted and with different binding posts for the 110 volt and the low voltage sides and also name-plated can give the student added valuable experiences in experimental set-up.

There are four types of alternating-current motors that may be investigated.

A. *Series or "Universal" Motor.* Students can make no major errors which must be provided against, except poor or wrong position of brushes on the commutator. This could cause the motor to draw excessive current. Starting voltage of this type of motor may be 6 volts,[14] but this voltage after the start may be reduced with a variable rheostat[15] to about 3 volts. The observations that should be made with the aid of questions or by other methods are: 1. this motor is *self-starting;* 2. *reversal of rotation* may be achieved by the interchange of connections either in the field coil or in the armature, but not in both simultaneously; 3. *regulation of speed* can be secured by current control through a variable rheostat; 4. the *low current consumption* of this type of motor may be observed; 5. the correct position of the brushes can be found experimentally by a maximum speed observation rather than by meter reading; 6. the position of the brushes does *not determine the direction* of rotation as is the case of the repulsion motor.

B. *Repulsion Motor.* With the brushes on the commutator shorted with a stout copper wire and current being supplied to the field coil only (10 volts—5 amperes starting), this motor in the two pole model is *not self-starting.* It has *regulation of speed* with current control, and

[12] Weaver, Elbert C., "Two Laboratory Motor Variants," School Science and Mathematics, 45: 598 October 1945.

[13] *Experiments with Electric Motors and Generators.* Cambosco Scientific Company, Boston, Mass., 1935.

[14] Meter readings were taken on the Genemotor. The St. Louis Motor requires slightly higher currents.

[15] School Science and Mathematics, 48: 257, April 1948.

will run at 6 volts—3 amperes, when resistance is added to the field coil. The *position of the brushes* is rather critical. *Reversal* of rotation can be produced by rotation of the brush position through 90°. This fact greatly intrigues students. A meter put into the brush circuit is an added source of wonder. It may be shown that the *current consumption* of the repulsion motor is higher than in the series motor. Students should be warned that these motors operate poorly or not at all when heated. To dramatize the action of this motor a contact key may be used in the brush circuit in place of the short-circuiting wire. The motor will run only as long as the contact key is closed. *Manual start* may be necessary in the experimental models.

C. *Induction Motor*. It will be difficult to convince students that short-circuiting the commutator with a heavy copper wire produces a motor with entirely different characteristics. The consideration that this changes the direct current armature into a squirrel-cage rotor and the comparison of the characteristics of the induction motor with those of the repulsion type ought to clear up the doubts. Low resistance and good contact on the commutator are essential. It is not unusual to find that this motor requires *more* current than the series motor does to start (5 amperes in the experimental models), but it can be operated continuously at 3 amperes. The motor runs equally well in *either direction*, but requires manual start. It is rather sensitive to load (friction). Once in operation this motor is essentially synchronous, but speed regulation[16] is possible in the experimental models with a rheostat.

D. *Synchronous Motor*. Of all the alternating-current motor experiments the synchronous motor is the least satisfactory in performance for student investigation. There are two types of this motor which may be investigated in the experimental model. One kind consists of an alternating-current carrying field coil with which the rotor has no connection except a magnetic one. The other kind uses a permanent magnet, or a direct-current electromagnetic field, while alternating-current is delivered into the slip rings of the rotor. In this later variety which requires *large currents* (5 amperes) for operation, overheating is all too common. Some observation made by students, v.g., *current consumption* may lead to false conclusions as to the value of this kind of motor. While results obtainable on successful operation are not impressive, the whole synchronous motor investigation adds little to the appreciation of alternating-current motors. Due to the uncertainty of successful operation by manual start, neither kind of motor is popular with students. Observation to be made or empha-

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[16] False notions caused by student experiment must be guarded against. While in two pole experimental motor speed may be controlled this will not happen in commercial motor, running at synchronous speed.

sized in the synchronous motor are: 1. both types of motor require *manual impulse* of a fairly high velocity to start them; 2. both varieties easily pull out of phase and stop. These motors are very sensitive to load (friction). 3. ***position of the field*** is rather critical; 4. this type of motor *is reversible*, but only by manual impulse; 5. ***no regulation*** of speed is possible, but the motor will run on sub-multiples of the impressed frequency.

It must be evident that all four of these investigations can never be accomplished in a single laboratory period. How much of this is to be adopted will depend on the nature of the course offered, whether it is given as an appreciation course, or it is of a college preparatory nature. Much will depend on the attitude, maturity, and the skill of the students.

THE QUIZ SECTION

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1. A particle suspended by a string is pulled aside by a horizontal force. Show that no finite horizontal force can make the string perfectly horizontal.
2. A sphere laid upon a rough inclined plane of inclination θ is on the point of sliding. Show that the coefficient of friction is 2/7 tan θ.
3. A particle is dropped and one second later another particle is thrown downward with an initial velocity of 10 ft/sec. When will they meet? Examine the results!
4. A particle suspended from a fixed point by a string of length L is projected horizontally with a speed $\sqrt{\frac{7}{2} Lg}$; show that when the string becomes slack the particle has risen to a height $3/2\ L$.
5. Two men of different weights coast down a hill on identical bicycles. Which will reach the bottom first?
6. A small marble is allowed to ROLL from the top of a large sphere. A small block is allowed to SLIDE from the top of the sphere. Which leaves the sphere first? Which lands farther from the sphere?

MORE SUNSHINE PUTS MORE SUGAR IN APPLES

Apples have more sugar if they get more sunshine during the growing season. This was learned at Cornell's Agricultural Experiment Station in a long-time study aimed at correlating some of the factors like rainfall, amount of sunshine, and temperatures to the keeping quality of apples.

Another discovery was that the higher the temperatures during the last six weeks before harvest, the greater has been the amount of scald in storage. The scientists will test this information further during the 1948–49 storage season, based on predictions made the last six weeks before harvest. Such knowledge, they say, will be of value to growers, who could move scald-susceptible varieties out of storage rapidly if considerable scald were expected.

THE SCIENCE LECTURE IN THE HIGH SCHOOL ASSEMBLY

II. RADIOACTIVE ISOTOPES

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A short time ago I had the pleasure of addressing you on the general subject of "Atomic Energy."[1] Today I wish to tell you something about "Isotopes"—what they are, and how useful they have proved.

Let us first learn the meaning of the term "Isotope." In the year 1869 a Russian scientist by the name of Dimitri Mendelejeff stated what has since become known as "The Periodic Law." A practical statement of this law may be made in the form of a table with columns running up and down and across. Such a table finally came to consist of a series of blocks or boxes, making up a structure nine[2] blocks wide from left to right and nine blocks deep, up and down (Plate I). Mendelejeff discovered, by placing the lightest element in the first block and all the other known elements in the successive blocks in rows from left to right, according to increasing *weight* of the atom, that all elements take their places in this table in such a way that any element in the table has great chemical similarity to any other element above or below it in the same "up and down" column of blocks. We must here add, by way of exception, that some blocks had to be left vacant, because if some elements were placed next to the elements which they should follow, they would not resemble the elements above and below them. For such elements as many spaces (one or two) had to be skipped, until a correct place was found for them. These skipped or empty spaces or blocks merely meant that the elements which belonged in them were not known at the time, but were discovered later. This enabled Mendelejeff to predict, correctly, the discovery of new elements. We must also note the further exception that this table begins with Helium, not Hydrogen, and that Lanthanum and the "rare earth" elements are all placed in one block. Time prevents my discussing the reasons for these exceptions.

You will remember that an atom is composed of three types of particles, namely neutrons, electrons and protons (the latter two in equal number). The number of protons and neutrons, added together, is called the atomic weight. The number of protons alone is called the

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[1] "The Science Lecture in the High School Assembly—I. Atomic Energy," SCHOOL SCIENCE AND MATHEMATICS, December, 1947.

[2] The Helium ("zero") group of elements was unknown in Mendelejeff's time, hence his table would have been only eight blocks wide.

atomic number. As a consequence of the work of the British scientist Henry G. Moseley, the elements in Mendelejeff's table were rearranged according to *atomic number*, not atomic weight, and this is the present arrangement. Each of the blocks spoken of previously is therefore given a number—that is, the atomic number of the element which occupies that space or block. You will further remember that it is possible to have (either in nature, or by preparation in the laboratory) several forms of the same element, differing only as to the number of neutrons present in the nucleus. Since the number of protons in these forms is the same, they will all have the same chemical properties and the same atomic number. They will all therefore belong in the same block or "place" in our table. They are therefore called "isotopes," meaning "in the same place." Note that they do differ in one respect—their atomic weights. Isotopes are therefore defined as elements having the same atomic number (and therefore the same chemical properties), but different atomic weights (see Plate I—Carbons 12, 13 and 14). Theoretically the number of isotopes of an element is large because every time a neutron adds on to the nucleus of an element, a new isotope forms. In passing I should like to point out another interesting thing, of no importance for us at this moment, however, namely, that it is possible to have two different elements, (therefore having, of course, different atomic numbers) with the *same* atomic weights. Such elements are called Isobares. I do not wish to emphasize "Isobares" today. *Isotopes have the same atomic number, but different atomic weight, while isobares have the same atomic weight and different atomic number.*

Isotopes have come into great use in recent years. The Department of State report entitled "The International Control of Atomic Energy (June 1946) says, "*The importance of a continuing large supply of this material*" (that is, the isotope of carbon, with atomic weight 14,—designated C-14) "*for research is so great that existence and operation of chain reacting piles could be justified for C-14 production alone. It is entirely within the realm of possibility that discoveries made in researches with C-14 may be as important and far-reaching as the discovery of fission itself.*"

As I have said a moment ago, an element is capable of existing in many isotopes of itself. These isotopes are designated by stating the atomic weight of each one after its name or symbol. For example Carbon 14 or C-14 means the isotope of carbon with an atomic weight of 14. Since ordinary Carbon has an atomic weight of 12, C-14 means carbon with two neutrons more than would be present in ordinary carbon, which is C-12.

The first known isotopes were found in nature mixed with each other. For example, ordinary spigot water contains one part in every

PERIODIC ARRANGEMENT OF THE ELEMENTS WITH THE ATOMIC NUMBERS

The atomic numbers are printed in boldface. The approximate atomic weights are given

Periods	Group 0	Group I		Group II		Group III	Group IV		Group V		Group VI		Group VII		Group VIII
	The Inert Gases	Sodium Family	Copper Family	Calcium Family	Zinc Family	Boron, Aluminum, and Rare Elements	Carbon Family	Tin Family	Rare Elements	Nitrogen Family	Chromium Family	Oxygen Family	Manganese	Chlorine Family	Iron Family Platinum Family
1	**2** Helium *He=4*	**3** Lithium *Li=7*			**4** Glucinum *Gl=9*	**5** Boron *B=11*	**6** Carbon *C=12*, also *13 & 14** (isotopes of *C=12*)			**7** Nitrogen *N=14*		**8** Oxygen *O=16*		**9** Fluorine *F=19*	
2	**10** Neon *Ne=20*	**11** Sodium *Na=23*			**12** Magnesium *Mg=24*	**13** Aluminum *Al=27*	**14** Silicon *Si=28*			**15** Phosphorus *P=31*		**16** Sulphur *S=32*		**17** Chlorine *Cl=35.5*	
3	**18** Argon *A=40*	**19** Potassium *K=39*		**20** Calcium *Ca=40*		**21** Scandium *Sc=45*	**22** Titanium *Ti=48*		**23** Vanadium *V=51*		**24** Chromium *Cr=52*		**25** Manganese *Mh=55*		**26–27–28** Iron *Fe =56* Cobalt *Co=59* Nickel *Ni=58.7*
			29 Copper *Cu=63.5*		**30** Zinc *Zn=65.5*	**31** Gallium *Ga=70*		**32** Germanium *Ge=72.5*		**33** Arsenic *As=75*		**34** Selenium *Se=79*		**35** Bromine *Br=80*	
4	**36** Krypton *Kr=83*	**37** Rubidium *Rb=85.5*		**38** Strontium *Sr=***87.5**		**39** Yttrium *Yt=89*	**40** Zirconium *Zr=91*		**41** Columbium *Cb=93*		**42** Molybdenum *Mo=96*		**43** Rhenium *Re=*		**44–45–46** Ruthenium *Ru=102* Rhodium *Rh =103* Palladium *Pd =107*
			47 Silver *Ag=108*		**48** Cadmium *Cd=112*	**49** Indium *In=115*		**50** Tin *Sn=119*		**51** Antimony *Sb=122*		**52** Tellurium *Te=127.5*		**53** Iodine *I=127*	
5	**54** Xenon *X=130*	**55** Caesium *Cs=133*		**56** Barium *Ba=137*		**57** Lanthanum *La=139*	**58** Cerium* *Ce=140*		**73** Tantalum *Ta=181.5*		**74** Tungsten *W=184*		**75** Mazurium *Ma=*		**76–77–78** Osmium *Os =191* Iridium *Ir =193* Platinum *Pt=195*
			79 Gold *Au=197*		**80** Mercury *Hg=200.5*	**81** Thallium *Tl=204.5*		**82** Lead *Pb=207*		**83** Bismuth *Bi=209*		**84** Polonium *Po=210*		**85**	
6	**86** Radon *Rd=222*	**87**		**88** Radium *Ra=226*		**89** Actinium *Ac=*	**90** Thorium *Th=232*		**91** Uranium X^2 $Ux_2=$		**92** Uranium *U=238*				

* Between cerium and tantalum in the third long period lie 12 elements classified as *rare earth metals* with atomic numbers ranging from 59 (praseodymium) to 71 (lutecium). Their study is very difficult and their position in the table is somewhat uncertain.

PLATE I. Atomic Numbers in Boldface. Atomic Weights in Italics, (Adapted from "A First Book in Chemistry"—Robert A. Bradbury)

5000 of a form of water known as "heavy water" or deuterium oxide. Heavy water is so called because the hydrogen in it is heavier than ordinary hydrogen. This is so because the nucleus contains an extra neutron. We see therefore that heavy water contains hydrogen which is an isotope of ordinary hydrogen. This heavy isotope would be designated H-2.

Since the invention of the "atomic pile," isotopes have been prepared artificially. This is done in one of two different ways:—a) when uranium undergoes fission or splitting, many fragments of this element are formed which are radioactive isotopes of elements of lower atomic weight (in other words, radioactive isotopes of lighter elements are formed by transmutation of uranium). These isotopes are then separated and used. b) The element, of which isotopes are desired, is put into a radioactive pile and subjected to bombardment by the neutrons which are so abundant in a pile. Some of the nuclei of the atoms of the element are struck by these neutrons and form one or more isotopes.

By whatever method an isotope is made, it may prove to be radioactive. In any nucleus there is a delicate balance of forces between the protons and neutrons. (The element tin, for example, has ten isotopes—that is the neutrons can range from 62 to 74 in number, and each isotope be stable—that is, not radioactive.) But some elements, when neutrons are added to their nuclei, form unstable products—that is, the forces inside the nucleus are unbalanced. This situation tends to correct itself and become balanced by giving off high speed charged particles. These high speed charged particles are generally accompanied by strong, electromagnetic waves, which bear a similarity to X-rays and are very penetrating. The high speed particles are electrons and are called "*beta-rays*." The electromagnetic waves are called "*gamma rays*." When one or both of these rays are released we say an element is "radioactive." [This is true of isotopes of light elements. Radioactivity of heavy elements results in the release of heavy particles—either neutrons or "*alpha rays*" (atoms of helium, lacking their external electrons, hence really helium "ions.")] The medicinal virtue of the radioactive isotopes depends upon their gamma rays, except in the case of radioactive gold which, as we shall see later, depends upon beta rays.

Thus we see that radioactive isotopes may be made artificially in an atomic pile. But making them is no sufficient guarantee that we may be able to use them, for they tend to change into inactive forms. The length of time which it takes a radioactive substance to become half as radioactive is known as the "time of half-life." For some radioactive isotopes the time of half life is a few minutes, so you can see such a substance would hardly be useful.

Radioactive isotopes are not sold by their weight, nor are they sold 100% pure. Since the important thing is the amount of radiation which they give off, they are sold by the unit of radiation, called the "*millicurie.*" A "millicurie" is the quantity of an isotope which produces 37,000,000 atomic disintegrations per second, the same number produced by a milligram of pure radium element. You can therefore see that values familiar to you will turn topsy-turvy. For example ordinary sulphur is very cheap and ordinary gold very expensive. But radioactive sulphur, with a time of half life of about 87 days, costs $33.00 a millicurie, while radioactive gold, with a time of half-life of less than 3 days, costs only 15 cents per millicurie.

Now the question arises as to how these isotopes have been turned to useful purposes by man. In order to understand the answer, we must first grasp one idea, that is, though Nature seems either not to know the difference between isotopes of the same element, or does not care, man can tell the difference. One way of profiting from this fact is to use it in order to find out what an animal body does with a certain food or drug. For example, a compound containing one or more radioactive atoms can be either fed or injected into an animal, and by means of a Geiger counter, this compound can be traced as it passes through the body, without killing the animal and performing an autopsy. The results obtained are swift, clean and humane. Another use of the fact that Nature is not "too particular" about special isotopes is their use in animal diseases. Certain diseases being curable by radiation, a chemical compound, which, when administered, goes normally to the diseased area is selected and made radioactive by being placed in an atomic pile. When this substance is administered and absorbed, the body is "fooled" about its being radioactive, (that is, does not behave as though this difference mattered) and transports it to the usual place, where it cures the disease by giving off radiations without injuring the body, and finally becomes inactive and harmless. If radium were put into the body it would continue to be radioactive indefinitely and would finally become injurious.

Another advantage over radium is that isotopes may be given internally to a patient, while radium would have to be placed into an incision on the patient or applied externally. If applied externally it would injure all the healthy tissue before it reached the tissue which the doctor was trying to cure. Since some correctly chosen isotopes can go to certain desired places in the body, diseases in those places can be cured by radiation from these isotopes by giving an easily regulated dose for an exactly controlled length of time. *Some medical authorities believe that atomic energy, in the form of isotopes, has already saved more lives than it destroyed in both bomb-*

ings of Japan. The use of isotopes in medical research has a great advantage over the use of chemical methods. If a chemist wished to study a defective thyroid gland a surgeon would have to perform an operation to remove a sample of that gland from a person. Obviously that would not be desirable. Furthermore the amount of iodine for which he would be looking is extremely small and therefore difficult to measure. Lastly the gland would die as a result of the operation so that he could make no further studies of it. By the use of radioactive iodine he can detect the smallest amount of iodine and furthermore no operation is needed—the scientist can place a Geiger counter outside the body, near the organ being studied. Another advantage is that he has not killed the gland—he can return to it to study it as long as he wishes to.

So far isotopes have proved very useful in three fields, namely industry, scientific research (chiefly biology and related fields) and medicine. About ten elements have become outstanding. These are Carbon-14, Sodium-24, Phosphorus-32, Iodine-131, Iron-55, Sulphur-35, Chlorine-36, Gold-198, Potassium-42 and Calcium-45.

Carbon-14

This contains two neutrons per atom more than ordinary carbon, which is C-12. It is prepared at Oak Ridge by sealing calcium nitrate, $Ca(NO_3)_2$, in an aluminum can and inserting it into a uranium pile. The neutrons given off by the uranium bombard the calcium nitrate, changing nitrogen 14, which has an atomic number of 7, into carbon 14, which has an atomic number of 6. This results from the loss of one proton and one electron by the nitrogen reducing the atomic number to 6, the correct atomic number for carbon. (Plate II) Thus nitrogen is transmuted into carbon or nitrate into carbonate. At the same time a neutron is absorbed, thus taking the place of the lost proton, and keeping the atomic weight steady at 14. The calcium nitrate has thus been changed to calcium carbonate, containing C-14. Now this calcium carbonate is heated to 2000° causing carbon dioxide (containing C-14) to come off as a gas. This carbon dioxide can be made into Barium Carbonate, or any one of a number of organic chemicals useful in medical research[3]—for example acetic acid, formic acid, acetaldehyde, lactic acid,—or potassium or sodium cyanide for organic synthesis, etc. To give some idea as to how small a quantity is employed in research we may note that the carbon present in the compounds mentioned above may not be more than from three per cent to five per cent

[3] Barium carbonate may be reduced to Barium carbide. This, when treated with water releases acetylene gas, which can be converted to acetaldehyde, then acetic acid. The carbon will remain radioactive throughout all of these transformations.

C-14. It would be too difficult to purify it until it were 100%, and it is not necessary to do so in medical experiments.

Carbon 14 has been extremely useful in studies upon the human body and its chemistry, in connection with cancer research and even for studies upon the normal functioning of animal organs. For example:

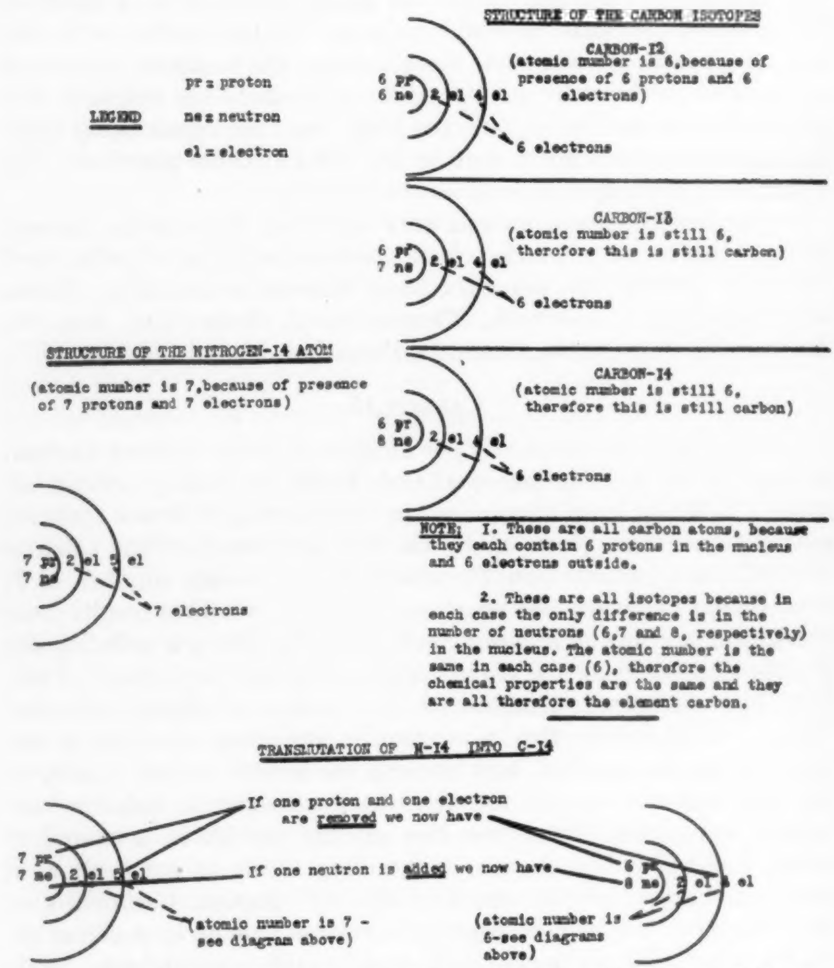

PLATE II. Atomic Structures and Transmutation of N-14 Into C-14.

We know that plants take in and use carbon dioxide. The question arises as to whether animals also make use of this gas, for some purpose or other. By permitting animals to breathe in carbon dioxide containing radioactive carbon (C-14), it has been possible to trace such carbon, because of its radioactive effect upon such de-

vices as Geiger counters, etc. Such radioactive atoms are called "*tracer atoms*" or "*tagged*" or "*labelled*" atoms. By means of such a study, the carbon dioxide has been traced to the compounds urea, uric acid, glucose and glycogen, thus proving that animals as well as plants do use carbon dioxide. The reverse kind of study has also been made—i.e. the carbon dioxide exhaled by animals has been traced back to compounds present in the kidneys and liver. Studies made upon pigeons have enabled medical scientists to trace the formation of uric acid in human beings, that is, we now know

PLATE III. Radioactive carbon in leaves, which take their own pictures.

the transformation which food undergoes when it makes uric acid in the body. This knowledge will be useful in treating certain human diseases.

Carbon 14 has also been useful in the study of plant physiology and in the tremendously important process of photosynthesis, during which carbon dioxide is absorbed and oxygen released, sugar being manufactured as a result. This process of photosynthesis and how it takes place is one of the greatest interests of plant physiology and agriculture. At the University of Chicago scientists placed some plants into an atmosphere of carbon dioxide containing C-14. Light was allowed to shine upon the plants for thirty seconds. The radioactive carbon dioxide was absorbed by the plants, and, under the influence of the light, the plant started to carry out photosynthesis.

The tissues of the plants were then quickly examined, in order to find out what had happened to the radioactive carbon (C-14). While it is too early to make a full report at the present moment,

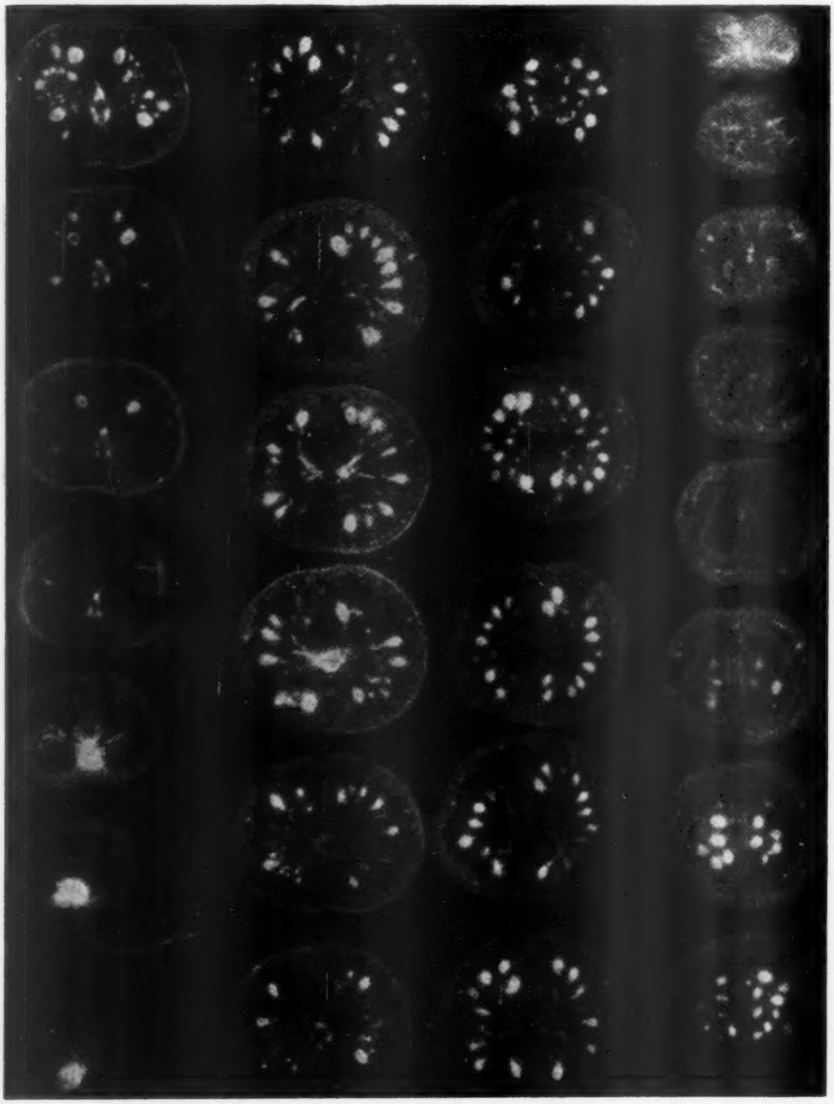

PLATE IV. Radioactive zinc in tomato plants. The smallest trace of zinc is present, yet the tomatoes sparkle.

we can say that the carbon was found to have formed a compound, which although not yet definitely identified, is most probably the first compound formed when a plant is carrying on its photosyn-

thesis. From this point on it will be straighter and easier sailing for scientists to learn much about the problem of plant processes. It was the special property of radioactivity in the C-14 which enabled these scientists to trace the carbon by means, for example, of a Geiger counter. For this reason, such an isotope is called a "tracer atom." (Plates III and IV)

Before leaving the subject of radioactive carbon, I should like to tell you a little more about its use in medical studies. At a Boston Hospital three doctors, "tagged" a protein-building amino-acid by the name of "l-alamine" with radioactive carbon and studied the behavior of cancer tissue and normal liver tissue in test-tubes. They noted that the cancerous liver absorbed the amino acid much faster than did the normal liver. It is hoped that some day such experiments may lead to an understanding of why cancer cells grow so much faster than do normal cells. Much has been learned about life processes by the following technique: Some food substance is prepared so that it contains a very small amount of a radioactive isotope. The living body treats this isotope as though it were the ordinary element and permits it to travel about as though it were an untagged molecule. The passage of this "tagged" material through the organs of the body is easily traced by means of a Geiger counter. In this way we have learned much about how drugs, hormones and vitamins act upon the body, the method by which fats and sugars are burned in healthy bodies, as well as in persons suffering from diabetes, and even found partial answers to some of the difficult problems of plant and animal heredity. Perhaps we will soon also learn by the use of tracer atoms how and why cancer spreads through the body. If so, we would know much about its prevention.

We now leave the subject of carbon-14 with the final remark that this isotope has been eagerly accepted by biologists and medical research workers, because of its wide use as a tracer substance in studying all kinds of problems of growth, heredity and disease. When it was made in the cyclotron, it used to cost one million dollars per millicurie. Now it costs fifty dollars per millicurie and is obtained from the "pile." The time of half-life is more than 5000 years.

Sodium-24

Ordinary sodium is Na-23. Sodium-24 therefore differs from Na-23 in that it contains one more neutron in its nucleus. It is used in studies of heart disease. When a solution containing radioactive sodium is injected into a patient's veins, the course of the "tagged atoms" may be followed by placing a Geiger counter over the heart and recording the appearance of the tagged blood on a special in-

strument. By this method enlarged hearts can be sooner detected than by any other known method. Another use of radioactive sodium is as an aid in deciding whether arm or leg amputations are necessary, due to danger of gangrene caused by injured blood vessels. After an injection of radio-sodium the injured member is studied with a counter to see whether little or much blood is circulating through it. If the circulation proves to be not too badly impaired, the operation is unnecessary. Many limbs have been saved in this way. It is also used to study "trench foot" for similar determination of the amount of damage done by disease. Studies with radioactive sodium have enabled scientists to follow the passage of sodium in and out of cells and have shown our older theories about this passage to be incorrect. This will some day lead to a better knowledge of the life processes of the cells of our bodies. One draw-back to radio sodium is its short time of half life—about 15 hours.

Phosphorus-32

This isotope contains one more neutron than ordinary phosphorus, which is P-31. It has been of great value in studying cells in health and disease. An example is the introduction of this isotope into the food of animals and then, by means of its radioactivity, measurement of the amount of phosphorus-containing protein which moves out of the nucleus of a cell. This study would not be possible with ordinary phosphorus. Even bacteria are now being tagged with radioactive phosphorus! By this method it is hoped that we may be able to learn how disease germs enter the body and how they do their damage. Another use of radio phosphorus is in the formerly always-fatal disease called leukemia. In this disease the white blood cells become too numerous and destroy the red blood cells. When radiophosphorus is used the number of white cells is sharply reduced and the patient shows considerable improvement. Another disease treated with radiophosphorus is Polycythemia Vera, a sickness of the cells which make red blood cells. This condition is relieved by the use of radiophosphorus externally—the isotope, in solution, may be wiped over the surface of the body. Radiophosphorus is also used in research on tuberculosis and in studies of metabolism in plants and animals. For example, this isotope has disclosed how plants use the phosphorus in fertilizer. Its time of half life is 14 days, a fairly comfortable length of time.

Iodine-131

Since ordinary iodine has an atomic weight of 127, this isotope contains four extra neutrons. It is used in the treatment of two diseases of the thyroid gland. One disease is thyroid cancer, the other

hyperthyroidism, or thyroid over-activity. The thyroid gland regulates the speed with which we use our food (metabolism). Radioiodine is used to detect and cure over-activity of this gland by giving the patient a small dose of it and then measuring the radioactivity of the thyroid by means of a counter. If the test shows that too much iodine has been absorbed, the doctor can tell that the thyroid gland is "acting up." Radioactive iodine has also been used in the study of cancer of the kidneys in rats. When introduced into the body of an animal by mixing with food or some other method, it goes to thyroid gland and kidneys and by the radiation which it gives off, destroys cancer cells located there. Thus a surgical operation is not necessary. Interesting studies concerning hormones in plants and animals have been made with radioiodine. Thyroxin, the hormone present in the thyroid gland was found to be manufactured in other tissues as well as this gland, by the following experiment. The thyroid gland of an animal was removed, then some radioiodine introduced into the animal's body. The protein of various tissues of this animal was then removed and examined for the presence of thyroxin, the thyroid hormone. Radioactivity having been found in the other tissues, the conclusion was drawn that they can manufacture small amounts of thyroxin. The time of half life of Iodine-131 is eight days, a fairly convenient period.

Iron-55

Ordinary iron having an atomic weight of 56, this isotope is lighter by one neutron. If a bit of it is put into food, it will show up in the red blood cells in a few hours. The circulatory systems of plants, which are both slow acting and intricate in character, are being studied by feeding them radioactive iron. It has also been used in studying plant diseases, as well as anemia, preservation of blood and in industry, to learn more about the wear which friction has upon machine bearings. By studying radioactive iron in the form of steel it is possible to tell whether so small an amount as one hundred-billionth of an ounce of metal is transferred from one bearing surface to another. The time of half life is relatively long—four years.

Sulphur-35

This isotope contains three more neutrons than ordinary sulphur-S-32. Interesting studies have been made upon the wonder drug "penicillin" by means of S-35. Penicillin molecules were tagged with radiosulphur and then the course of these molecules traced through the human body. In this way it was possible to learn where penicillin goes and what finally happens to it. Another interesting study made

upon radiosulphur was carried out by a large steel manufacturing firm. Steel is harmed by the presence of sulphur, which gets into this metal from the coal used in the process of manufacture. Since there are two types of sulphur in coal, "organic" and "pyritic," this firm had a study made of both types, by the use of radio-sulphur, for the purpose of finding out which kind they should avoid. The study showed that there was no advantage in taking the trouble of buying the kind of coal which contained one special variety of sulphur, to the exclusion of the other. Radiosulphur has also been used in studies in plant physiology and in proteins. It has been proved, for example, that plants can get their sulphur from either the air or the ground. The time of half life is 87 days, a convenient length.

Chlorine-36

This isotope if present in about equal amounts with Cl-35 in ordinary chlorine gas. Atomic weight tables therefore give the atomic weight of chlorine as the average of 35 and 36, namely 35.5. It is used in studies on plant and animal physiology. Its time of half life is one million years!

Gold-198

Ordinary gold being Au-197, this isotope contains one more neutron. Radioactive colloidal gold has been used with some success to treat certain sub-surface cancers. This effect is brought about by an unusual means. Generally a cancer cell is destroyed by ultra-short wave radiations like X-rays and the gamma rays. Gold however gives off high speed electrons which are effective in killing the rapidly-multiplying cells. Some one has also proposed the use of "gold rays" for making extremely accurate measurements, as for example in grinding optical lenses, and for the inspection of castings, weldings and forgings. The time of half life is short—about 3 days.

Potassium-42

This isotope contains three more neutrons than K-39, ordinary potassium. It is used in studying diseases of the heart and nervous system and has a very short time of half life—about a half day.

Calcium-45

Ordinary calcium is Ca-40, and Ca-45, therefore, contains five more neutrons. It is used in studies on plant nutrition, the action of fertilizers, and the formation of bones. Its time of half life is about one-half year.

By using radio-arsenic it has been shown that plants do not absorb

this insecticide from the soil. The use of radioisotopes seems to be about to cause a revolution in agriculture.

Radioisotopes, it should be remembered, are dangerous to handle. Some of them can kill in the very smallest specks. Only skilled scientists know how to manipulate them safely. The skill in handling them that is being acquired is now considered far more valuable than the temporary "secret" of the atomic bomb. The Atomic Energy Commission has stated, in a report on radioisotopes that "should an atomic war occur, it would be essential that as many scientists as possible be trained in the technique of working with radioactive material." I have tried to tell you today how isotopes have already revolutionized biological and other fields of research. They are becoming important in fields such as chemical industry where they can now be used for modifying chemical reactions. It is thought that they will soon bring about a change in the Bessemer steel industry. In this method of producing steel the impurities of molten steel are burned out by means of a blast of air. Phosphorus, a harmful impurity, leaves the steel only after all other impurities have gone. By adding a little radiophosphorus to the steel, it would be possible to know with great accuracy how soon to turn off the blast of air, because the two isotopes of phosphorus would leave together and thus the steel would be finished as soon as radioactivity disappeared. Today we must be guided by chemical analysis, which is more time-consuming. It is probable that isotopes will find use in the manufacture of plastics, gasoline, large scale production of vaccine and in large-scale sterilization. It has been suggested that the future power-plant of a city will also provide, by the use of radiations, for pure water and disposal of sewage. Cold light may be another advance made possible by the large scale production of radioactive materials having long life and the discovery of suitable phosphors for this purpose. Such long-lived radioisotopes might also be employed to prevent dust explosions in flour mills by using them to remove the several-thousand-volt static charge generated by the moving machinery before the voltage produces a spark. During manufacturing processes textile fibers (and paper) stick together, due to static. It would be economically important and probably practical to control such sticking together by using radioactive isotopes. It would also seem possible to use the powers of the radiation from isotopes to bring about genetic changes in the bacteria of fermentation, food crops, cattle etc. Improved species might result which might have great benefit for mankind. Lastly, radiation itself—how it brings about its various effects, should be further studied because when we know more about it, we will have a better

understanding of the laws of physics and chemistry and thus find ever newer and better applications of isotopes.

Grateful acknowledgment is made to the following for their kind permission to reproduce the illustrations: Plate I D. Appleton-Century; Plate III Dr. Martin Kamen, Washington Univ.; Plate IV Dr. J. H. Hoagland, Univ. of California.

MATHEMATICS IN MICHIGAN

As a mathematics editor of SCHOOL SCIENCE AND MATHEMATICS there has been called to my attention a pamphlet prepared at the direction of the Michigan Section of the Mathematical Association of America and mailed by them to all the high schools of the state. This pamphlet, entitled "A Mathematics Student—To Be or Not to Be?" contains information about mathematics requirements for entrance upon some forty various courses and curricula in the colleges and universities of Michigan.

The pamphlet seems to offer an excellent means for the correction of misinformation regarding entrance to Michigan collegss. It clearly points out to the student that while it is true that he may enter many college courses without having taken any mathematics in high school, many other courses and curricula are completely closed to the student without high school mathematics. The student is warned to study carefully the programs at any college he may plan to enter, not merely the formal entrance requirements, but also specific course requirements; he is told to study the summary in the pamphlet, but that even these requirements may change. The summary is well prepared, it lists not only required mathematics, but also recommended courses.

This work should not only be of direct value to the student; it can not help but be of great value to high school administrators and counselors. If the material is read and heeded, many students will be saved time, money, and disappointment. The committee in charge is indeed to be congratulated on an excellent piece of work—perhaps other states might well need a similar study. In such case, there is little doubt that Professor Phillip S. Jones, of the Mathematics Department, University of Michigan, Ann Arbor, a member of the committee, would be glad to give any information which he thinks would be of help.

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VETERANS' ENROLLMENT DOWN

Veterans, who formed about half of the Nation's college student body in 1947, account for only 42 per cent of the total enrollment in 1948. Delaware, Florida, Maryland and New Mexico are the only States showing increases in number of veteran students this year. Greatest drop in veterans' enrollments came at the junior college level.

MEN OUTNUMBER WOMEN

Men still outnumber women almost 3 to 1 in the Nation's colleges and universities, the Office of Education survey reveals. The proportion of women students has changed little this year over last fall. The 3 to 1 ratio holds in the large universities, although it goes down to slightly less than 2 to 1 in liberal arts colleges, and is more nearly 1 to 1 in teachers colleges. The proportion of women freshmen is slightly higher in 1948 than it was in 1947 in all types of institutions.

THE EFFECTIVE ADMINISTRATION OF HIGH SCHOOL BIOLOGY TEACHING UNDER STATE SUPERVISION

PART III. THE PUPIL GETS C

CHARLES E. PACKARD
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Second in difficulty to the preparation of a fair, accurate, meaningful and otherwise suitable set of test questions, many educators would claim, is the proper correction of the answers received. Whether the examination is subjective or objective in type, thoroughly adequate knowledge on the part of the marker of the material covered or at least access to the same with the will to use it, is vital. Interpretation of an answer may often be required. Appreciation of exactly what is intended to be set forth and critical appraisal of how well the purpose of the question is met by the writer, these and additional qualifications enter into the problem to make striving for a wise after-reading and a common understanding of the issues involved profitable both for examiner and examinee. The routine of giving and taking becomes so frequent that carelessness is likely to be an accompaniment, quite without intent.

If the test is to be as objective as possible with results rated by formally st ndardized sheets or by machine, as is becoming the usual practice, there is every reason to prepare the questions so skillfully and so clearly that one and only one reply is obviously right. This calls for supreme wisdom in the choice of words and wide acquaintance with facts in all their varied implications. In two previous papers (1, 2) the author has commented at length upon syllabi and tests set up as instruments by state authorities in education departments for use in secondary school biology teaching. It has been shown that very careful correlation and follow-up are of great importance if there is to be achieved the most effective co-operation in program building between the teacher and pupils in the school and the supervisory organization.

No one would deny that the opportunities for disruption and interference with the smooth, harmonious development of such a course are likely to be many. If there is merit in the procedure, and time seems to have demonstrated to the satisfaction of the majority that such prevails, the perils along the way form no excuse for abandonment. However, any system stagnates which does not keep a watchful eye open for improvement or maintenance of the highest degree of attainment possible. It may be well for a somewhat impartial observer viewing the process from the sidelines, to offer criticism as need arises, for such will exist in any administrative effort.

A little of the background of the present study reveals better its causation and purpose. A radio broadcast has reminded state citizenry recently of the pertinency of the problem by mentioning certain routines entailed and calling attention to the fact that many hundreds of our young people everywhere are participating in testing programs periodically under way. One report spoke particularly of the care and exactitude by which papers were expertly prepared, the great secrecy attendant thereto, the extreme caution with which tests were mailed and guarded, the effort made to have local scaling followed by individual checks by a corps of 150 scorers at official headquarters. The undoubted impression was created that each paper was closely examined at least twice to ensure no mistake.

Parents who pay high costs for the education of their children do not resent the expense when they feel they are receiving value for what they render. Interested adult participation in school affairs cannot be seriously declining, although it probably could be bettered, if one is to judge by the activity of such groups as the PTA and similar congresses. It is understandable that some concern should be aroused when it becomes known that instruction is purportedly given by those who have never had more than a slight contact with a subject, or even none at all. Here the teacher is often an unwilling victim. There is also a case to be stated for the hiring board, superintendent, or principal. Yet surely the last of all these individuals cannot afford to turn a deaf ear on the comments of those persons most anxious but should do his best as the one to whom the total school welfare is entrusted to secure as good results as possible under specific conditions. The approach of state-administered examinations does involve problems. Results for pupils may be far-reaching. No wonder parents whose children find it highly desirable to secure a good record for future investment look forward to the ordeal with trepidation and uncertainty when it is realized that instruction has been below par.

The case of parent S illustrates the preceding. Disturbed over the type of preparation given she undertook to assist a child, in biology, for the official examination. In taking it, answers were first written out roughly then transcribed to the form provided. The "scratch" paper was taken home and later inspected by the tutor. When the grade was posted the mark seemed low. Doubts led to submission of the answers to a college biology teacher, an associate professor with Bachelor's, Master's and Doctor of Philosophy degrees from excellent departments, and a good teaching record in college of some years one of which had been as acting head of the biology division. The original grade given was by letter, B. The second scoring added enough points to bring it into an A range.

Several other parents became interested. The matter was finally referred to the author of this study. A second paper was secured, a "scratch" paper also, recovered from the waste basket where it had been thrown, on return from school, without comment. The author inspected both papers carefully, comparing them point for point with the question list supplied him. Allowing for possible mistakes in transcription it was agreed that the paper by S deserved higher rating; that the score of C which Y's effort secured was really B.

Following consultation, and review of all factors concerned, enough difference developed to justify request for hearing before administrative officials. From the series of talks resulting it was learned that the school instructor had, in some way not made entirely clear, received aid in correcting one or more of the class papers, or had been given one or more answers from an undetermined source to use as a check against his own evaluation. Probably a third biology teacher was consulted and the issue rested as originally decided. Evidential reports indicated, however, that certain grades were changed from their earlier posted status. The incidence of failure was high.

Y's paper was reviewed, point for point, not by the author but by a parent of Y, with an administrative official of the school who claimed that it could be given a much lower grade than the teacher had allowed. A check at state headquarters was also requested and later received. A portion of the courteous reply is quoted: "The rating assigned by the school we find to be correct. . . " Curiosity now being aroused in consequence of this and other events the author undertook to investigate the existent situation in some of its details.

It was learned that state examination questions are (a) founded on the state syllabus; (b) that "the question committee preparing these papers consists of a group of classroom teachers"; (see further comment) (c) that "in the case of each examination a careful check of the examination items is made against the syllabus in order that a balanced paper may be the result." The syllabus, its accompanying "scope-content outline" and the set of test questions involved have been carefully analyzed in the two studies cited at the beginning of this paper. No doubt the corresponding official stated sincerely his belief, in general, with regard to all state examinations issued from headquarters. As far as the particular biology examination at issue is concerned the informed reader may judge from its previous analysis as to how well it conformed to the broad characterization applied.

The least that this critic could say, in all fairness, is that the 1947 issue was far from flawless in numerous respects, such as phrasing, accuracy of statement, and clarity. The syllabus which formed the

basis for the test was prepared by (a) the head of a science department; (b) the head of a department of biology and general science of a large high school; (c) a university instructor in science education; (d) the state supervisor of science; (e) a teacher of general science and biology in a city high school. Thus it is not indicated that in this group there is a single person trained exclusively in biology nor is there a single nationally known college biologist among them who could serve as critic and consultant.

With all due respect to the qualifications and training of this group the author would like to mention the following as indicative of the tenor of the content and to serve as a sampling:

(a) "Scientific classification is based on structure."—(The categorical nature of the statement fails to mention at all the part played by function and development in taxonomy, e.g.) (b) "All living things grow by the multiplication of their cells."—(Unicellular organisms, both plant and animal, *grow* by increase in *volume* of their substance. Upon reaching the biological maximum of size, cell division, a form of reproduction, occurs.)

(c) "Animals . . . can improve or change their habitat."—(Very awkwardly stated. Certain animals and man can migrate into improved surroundings. Man has considerable ability to modify his living quarters.)

(d) "In one-celled organisms the protoplasm itself reacts to stimuli."—(What but protoplasm in the living organism ever reacts to stimuli?)

(e) "All multicellular organisms are further integrated by means of body fluids."—(What *body fluids* are possessed by large numbers of many-celled algae, fungi, sponges, coelenterates, rotifers, etc., etc.?)

(f) "Plants obtain their food from the air, soil and water under definite conditions of temperature and light that depend upon the sun."—(Accurately speaking they do nothing of the kind as the plant physiologists have tried very hard to show. Chlorophyll-bearing plants secure their *raw materials* in this way and *manufacture* the food they use, a very fundamentally different concept.)

(g) Speaking of "many-celled organisms" it is stated that "all cells must use oxygen for energy, that is, carry on respiration, but special cells are set apart to take it in and distribute it to all tissues."—(Many, many plant and animal species composed of numerous cells have nothing of the kind for oxygen intake and distribution.)

(h) "The single animal cell moves about in search of food, takes it in solid form, digests it and assimilates it."—(The statement overlooks attached and colonial protozoans, and the saprozoic protozoa that exist upon dissolved and decaying organic matter.)

(i) "The typical single plant cell can not move about and can take in food only by diffusion through its cellulose walls."—(What is an example of a "typical *single* plant cell"? The plant *flagellates*, botanically classified under the algae, bear chlorophyll, *make* their *food* instead of taking it in by diffusion just like any typical plant cell, and move about very freely.)

(j) "Cell division starts in the nucleus and proceeds by a definite process, called mitosis, which involves the chromosomes."—(Cell division *regularly* does so, is *mitotic* in type, but *may be direct* or *amitotic*. " . . . and *usually* proceeds, etc.," would, by the addition of one little word, have made an accurate, complete statement.)

Here are ten statements taken from pages 11–31 of a 60-page syllabus issued for the guidance of teachers and effective from the middle thirties to at least the middle forties, or a decade or more. It declares, page 17, " . . . examinations in general biology will be based largely upon the generalizations or truths listed in the general outline and plan of 'development' for the first eight teaching units." The 1947 test was very specific and factual. If teachers based their classroom drill in preparation for the finals on the syllabus, did they overlook its errors? With reference to the adoption and general usage of an elementary science syllabus the precaution is given " . . . it will be wise for teachers of general biology to take little for granted." Isn't it pertinent to enquire whether, in science teaching, anything should ever be taken for granted, even the presumably authoritative, unless buttressed by supplementary knowledge and experience?

It is exactly that enormous amount of accumulated information and firsthand contact with specimens, and those who specialize in their handling and experimentation, that adds force to the equipment of the advanced student. The more general the perspective the less likely is it that the not inconsiderable number of exceptions will be skipped. The author's experience in teaching subjects in their broad, general phases has taught him to be exceedingly wary of unqualified dicta. Possibly only one strictly classroom teacher of biology itself shared in the compilation of the syllabus. Very possibly also a headquarters test could be originated, and even corrected, by a series of *general science* teachers rather than by a purely biologically trained one with an extensive background in its many subdivisions and specific subjects. Hence the difference in result.

Furthermore, it is a very curious coincidence that in an examination of which a goodly portion was subjective, and therefore permissible of interpretation and estimation as to its correctness and accuracy, and requiring individual judgment on the part of the corrector as to how many points to assign to some portions, the "assistant examiner in the department" who checked Y's paper should reach exactly

the same numerical percent that the paper was originally accorded by the local secondary school teacher, namely 76.

Therefore, examination papers S and Y deserve analytical attention as achievement indicators for the efficiency of the state department in the objectives it seeks through administration of its ambitious and costly program of statewide tests. Did the departmental examiner rate the paper submitted conscientiously and fairly as though he had never known it was the subject of previous scrutiny? We presume so. What criteria did he use for his judgments? Syllabi, scope-content outlines, texts of high school or college grade; how much training and how much teaching experience? Or did he adopt a routine method of confirming, after some minor consideration or sampling, what he felt had been an original official figure that should be sustained? Analysis of the two reasonably typical sets of answers available from the class leaves the fair-minded reader somewhat appalled at possible consequences for the thousands of individuals who submit, in all classes, their efforts annually.

A point by point discussion of the two papers in all their details is beyond the scope of this criticism for it would lead to great length if nothing else. Enough can be demonstrated to cause us to wonder whether some re-thinking and revision might not be in order considering the high cost of the program.

(*To be concluded in February*)

NEW FLUORINE-CHLORINE PLASTIC VERY INERT TO CHEMICALS

Fluorine and chlorine make up by weight four-fifths of a new plastic which is an unusually stable, high-temperature material of the thermoplastic type, extremely resistant to chemical action. It is not brittle although strong and hard, and while particularly suitable for use at relatively high temperatures, gives satisfactory performance at low temperatures.

The new plastic is chemically a polymer of trifluorochloroethylene. That is, it is a form of this chemical in which many molecules are linked together to form giant molecules. It is a product here of the M. W. Kellogg Company, and will be be known as Kel-F. Commercial production is yet only in limited quantities. It was developed by Kellogg scientists in consultation with Dr. W. T. Miller of Cornell University who was the leader in the early work on the reactions of this fluorine-chlorine-ethylene chemical.

Kel-F is closely related to the interesting new family of organic compounds known as the fluorocarbons. In it, however, some of the fluorine is replaced by chlorine. Fluorocarbons are similar in structure to the hydrocarbons of petroleum, but differ in that all of the hydrogen is replaced by fluorine. The hydrogen is the point of chemical attack in the hydrocarbons. The absence of hydrogen gives the fluorocarbons, and Kel-F, extraordinary chemical inertness.

CUTTING THE COST OF HIGH SCHOOL CHEMISTRY

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Many administrators of small high schools feel that it is impossible to include chemistry in their course of study because the cost would be too great. This article suggests a method by which the installation of a chemistry laboratory can be inexpensive. This is done by using semimicro methods in the laboratories to be built.

During the past decade a few progressive teachers of college chemistry have switched to the semimicro for freshman instruction. These teachers have found that the change has much to recommend it. It seems logical that the high school laboratory should also be taught by semimicro methods. This is particularly true for the high school because of the great saving in money which the semimicro permits.

The accompanying illustration shows an installation used for the beginning course in chemistry. The rest of this article will describe in detail the setting up of such a laboratory. The simplified, economical apparatus which can be made or purchase will also be described.

The laboratory shown was in a basement room 32′ by 20′. Four wooden tables (dimensions of 12′ by 4′) covered with a battleship linoleum were placed in the room. Each table seated six students and cost $40.00. Each student at each period is given a clean, large-size paper towel on which to work. This protects the table top and is also used by the student at the end of the period to wipe his hands and the table top.

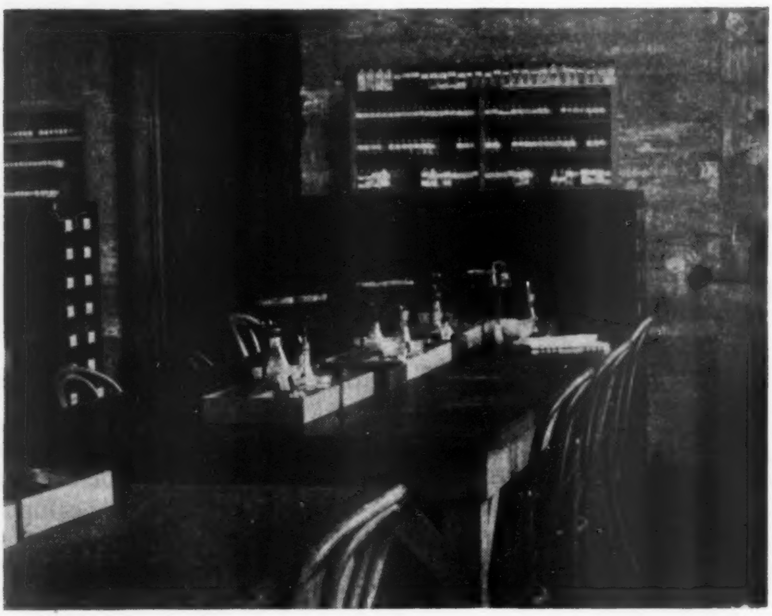
Each student station (six to a table) is provided with a wooden tray which is 9″ by 12″ by 3″. This tray has one partition. In the smaller 5″×9″ compartment is placed a wash bottle, twelve 3-ml. test tubes, two 100 mm test tubes, and one 150-mm side-arm test tube. All glassware is pyrex. A glass bowl is also put in this compartment to hold the wash bottle. This bowl is rectangular in cross section and was purchased for 15 cents at a variety store. It is the Fire King oven glass brand.

The bowl described above is used for a collecting trough for the gases which the student prepares. However, the principal use of the bowl is for a waste container. The student dumps all his waste liquids into the bowl and also his dirty test tubes. At the end of the period, he takes his dirty apparatus in the bowl to the one sink in the laboratory for washing. Near the sink is a dishpan of warm soap solution to aid him in cleaning his apparatus. This arrangement does away with the need of providing each table with sinks and plumbing. This in itself saves a great amount of the cost of the laboratory. Any water which the student uses at the desk is obtained from the wash bottle.

In the other compartment of the wooden tray is placed the following:

One	25-ml Erlenmeyer flask
One	50-ml beaker
Two	clothespins
Six	milk bottle caps
Six	creamers
One	10-ml graduated cylinder
Two	microscope slides
Three	stirring rods
One	pipette
Two	filter tubes
One	test tube rack

The clothespins serve as test tube holders. The milk bottle caps are used to cover the creamers which in turn are used as collecting



bottles for the gases generated. The teacher will discover that these creamers can be used for a number of tasks in the laboratory. The creamers can be purchased at restaurant supply firms at $2.20 a gross. The stirring rods are made by the students from 4-mm. rodding. The pipettes are also student-made from 6-mm tubing and fitted with a rubber bulb. They are really medicine droppers about 5 inches long. The filter tube is made from 10-mm pyrex tubing. One of the creamers contains absorbent cotton to be used in the filter tubes.

The test tube rack can be made in the school shop from a piece of

soft wood (preferably redwood) with dimensions of $8'' \times 2\frac{1}{2}'' \times 1''$. Twelve holes of the size to hold the 3-ml test tubes are bored through the wood. There are two holes for the 100-mm test tube and one hole for the side-arm test tube.

The cost of the tray and its equipment is \$2.80. This tray can serve as many students as there are sections of chemistry. The students do not have individual equipment. The equipment belongs to the station. Loss by breakage and other causes is not serious.

On each table there are three more wooden trays, $9'' \times 7''$ which are used to hold the bottles containing the chemicals to be used in the day's experiment. These bottles are of the dropper-stopper type and hold 30-ml. of solution. These solutions are made up in sets of one-half the number of stations in the laboratory. There should be shelving in the laboratory to store the sets of the various solutions when they are not being used. If 100 different solutions are to be used at sometime during the year, and if there are 24 stations in the laboratory, then about 1500 of these bottles should be purchased. They cost 5 cents each.

Solids are dispensed by the teacher at the time needed. For handling solids, each student should make a semimicro spatula by hammering out one end of a 6-inch length of aluminum wire.

For a ring stand a 14-inch iron rod is fastened to the table top. There must be a rod for each station. These rods can be cut and tapped by the local ironsmith. On each rod is placed a ring. The ring is covered with a wire gauze which is bent at the corners around the ring. This assembly of ring and gauze is left on the ring at all times.

The cost of the complete installation as described above was \$530. This laboratory serves 24 students at one time. To the above cost must be added the cost of chemicals. The semimicro method uses only one-tenth the starting materials that the macro method specifies. Hence, the qauntity of each chemical ordered should be cut correspondingly. The proper amount to order ranges from 1 oz to 1 pound. The cost of chemicals needed to start the chemistry course in semimicro should not exceed \$120. Yearly replacement for chemicals and apparatus should be less than \$100. Such a modest outlay should permit many small high schools to offer chemistry for the first time.

In conclusion, the arrangement of this laboratory has several advantages which should recommend themselves to the high-school administrator.

Since the students are seated during the entire period, the traffic problem is eliminated. The students are quiet as they feel intuitively that their classroom behavior is in order and not the usual carnival spirits which obtain in most science laboratories. Since it is quiet, the teacher has full control of the educational opportunities. He can

direct the procedures at all times; stress principles illustrated, warn of dangers, explain difficulties, etc.

This room can also serve as an excellent class room as well as a laboratory. The student is seated at a table and has a large space before him for writing. Thus, a room does not have to be tied up for chemistry alone. The room can be used every period of the day by any class. This should answer a valid objection to chemistry made by many high-school administrators who have only limited classroom space available in the small high school.

ARE HIGH SCHOOLS UNDEREMPHASIZING TRIGONOMETRY?

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Concern over the poor mathematical preparation of students entering college physics classes led the physics department of the University of Southern California to give to the general physics and the engineering physics students a set of questions regarding trigonometry and its relation to their preparation for college physics. The results obtained in studying the replies seem to indicate an undue lack of emphasis upon this subject in most high schools.

A sampling of approximately one-third of the students, 313 general physics students and 125 engineers, was used. The first question, "Did you take trigonometry in high school, in college or in neither?," netted the following results:

	In high school		In college		In neither	
General physics students (architecture, pharmacy, pre-medical majors)	113	36%	152*	49%	77	25%
Engineering physics students (plus physics, chemistry and math majors	74	59%	84*	67%	0	0%

* Many took it again in college after having had it in high school.

When one remembers that trigonometry is required as a prerequisite for engineering physics and is recommended before taking general physics courses, the low percentages who have high school preparation in trigonometry indicates that something is wrong. The large number of engineers repeating the course in college (26%) and the seventy-five percent of the general students who elected to take the course without being required to do so shows the importance which students themselves place upon this course.

It is of importance to know what percentage of students have not had trigonometry in high school, but in a solution to the problem it is perhaps more important to know if these students were ever advised while in high school to take trigonometry. One would suppose that every student planning to enter engineering in college or even those planning to study medicine, architecture, the physical sciences, etc., would have been advised to take the foundation courses necessary. The table below shows this lack of advice:

Question: Were you advised in high school by your high school advisor to take trigonometry, not to take trigonometry, or was no advice given?

	To take trigonometry	Not to take trigonometry	No advice
General physics students	24%	1%	75%
Engineering students	40%	1%	59%

The answers to the next question showed the penalties paid by the students for this lack of advice. The question was: "If you did not take high school trigonometry, has your college work been delayed by this lack?" The results:

	Not at all	One semester	Two or more	% delayed
General physics students	68%	25%	7%	32%
Engineering students	35%	52%	13%	65%

Thus we see that one-third of the students majoring in medicine, pharmacy and architecture or other fields requiring general physics courses in their curricula and two-thirds of the students majoring in physics, chemistry or engineering are actually delayed one or more semesters by this lack of advice in their secondary school experience. When one translates this loss of time into monetary terms, the cost of a poorly informed or an indifferent high school advisor becomes considerable.

But perhaps the school administrations do not realize the need for trigonometry and do not offer the course in a semester when the students who need it can take it. The next question tells that part of the story. "If you had no high school trigonometry, did your high school offer it during a semester when you could take it?"

	Yes	No
General physics students	67%	33%
Engineering students	61%	39%

This shows that one-third of those not taking trigonometry in high school could not have done so due to the failure of the administration to schedule classes in it. These cases make up roughly one-sixth of the students taking college physics and they have been denied an opportunity of taking high school trigonometry due to the high school principal's lack of appreciation of the subject's importance in their future careers.

Do the college students now feel that trigonometry is important as a course preparatory to college physics? The next question sought the answer to this by asking them to rank from 1 to 5 in order of importance the following five subjects in their high school work which had contributed to success in their college physics work. The average ranking given to the various subjects is given below: (the score 1.0 would indicate that every student agreed that subject to be most important; a 2.5 score means the subject is placed half way between second and third place in rank).

Subject	Engineering students	General students
Trigonometry	1.97	2.24
High school physics	2.19	1.99
2nd year algebra	2.61	2.26
Solid geometry	4.29	3.94
High school chemistry	4.43	4.21

This shows that students find trigonometry very important to insure success in college physics. It shows the unimportance of solid geometry, so often teamed with trigonometry by school administrators in planning a year's schedule. Second year algebra is ranked with trigonometry and high school physics as being important by both types of students. The physics department staff members at the University of Southern California, when asked to rank these same five subjects in order of importance, placed them in the following order: 1st, second year algebra; 2nd, trigonometry; 3rd, high school physics; 4th, sold geometry; and 5th, high school chemistry, with the first three being ranked very close together, thus agreeing substantially with the students.

In an effort to check upon the validity of this questionnaire the same questions were asked fifty students in El Camino Junior College (located in the suburbs of Los Angeles). Their answers were almost identical with those obtained at the University of Southern California. The wide range in type of secondary school and geographical location of such schools attended by the students of the University of Southern California prior to their matriculation makes it seem possible to

conclude that slighting trigonometry as a prerequisite preparation for college physics must be typical of many parts of the nation.

Summarizing, we find:

(1) Over half the students who needed trigonometry later, failed to take it in high school.

(2) Two-thirds were given no advice about taking it.

(3) The high school failed to offer it in one-third of the cases of those who did not take it.

(4) The cost to the students not taking trigonometry in high school was high. Two-thirds of the engineers and one third of the general students were delayed one or more semesters in college.

(5) College students placed trigonometry as important as high school physics for success in college physics, and placed solid geometry (the subject with which trigonometry is teamed in most high school curricula) as being relatively unimportant.

All this, at a time when the training of scientists is so important, seems to suggest a need for a drive on the part of the teachers of science and mathematics to educate the school advisors and school administrators to the importance of trigonometry.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

2101. *Proposed by Grace E. Hicks, Austin, Texas.*

If a, b, and c are unequal, find the conditions involving a, b, c, such that

(1) $$a \cos \theta + b \sin \theta = c$$

(2) $$a \cos^2 \theta + 2a \cos \theta \sin \theta + b \sin^2 \theta = c.$$

Solution by Max Beberman, Shanks Village, N. Y.

Let us assume that a, b, and c are non-zero.
Square (1):

(3) $$a^2 \cos^2 \theta + 2ab \cos \theta \sin \theta + b^2 \sin^2 \theta = c^2.$$

Multiply both sides of (2) by b:

(4) $$ab \cos^2 \theta + 2ab \cos \theta \sin \theta + b^2 \sin^2 \theta = bc.$$

Subtract (4) from (3):

(5) $$(a^2 - ab) \cos^2 \theta = c^2 - bc$$

for which

(6) $$\cos \theta = \sqrt{\frac{c^2 - bc}{a^2 - ab}}, \quad \text{the sign determined by } \theta.$$

Substituting (6) in (1) and solving for sin $\underline{\theta}$:

(7) $$\sin \theta = \frac{c}{b} - \frac{a}{b} \sqrt{\frac{c^2 - bc}{a^2 - ab}}.$$

But $\sin^2 \theta + \cos^2 \theta = 1$.
Hence

(8) $$\frac{c^2 - bc}{a^2 - ab} + \frac{c^2}{b^2} - \frac{2ac}{b^2} \sqrt{\frac{c^2 - bc}{a^2 - ab}} + \frac{a^2}{b^2} \left(\frac{c^2 - bc}{a^2 - ab} \right) = 1$$

(9) $$\left(\frac{b^2 - a^2}{b^2} \right) \left(\frac{c^2 - bc}{a^2 - ab} \right) + \frac{c}{b^2} \left(c - 2a \sqrt{\frac{c^2 - bc}{a^2 - av}} \right) = 1.$$

By labor it is shown that a, b and c can not be zero.
Two solutions by Francis L. Miksa and Grace Levitan, expressing *a and b* in terms of c and θ, were offered.

2102. *Proposed by Maude Henry, East Romulus, N. Y.*

Solve the two inequalities with positive square roots in all cases.

Solution by Hugo Brandt, University of Maryland.

$$f(x) = \sqrt{2x+1} + \sqrt{x-1} \lesseqgtr 36.$$

If

$$f(x_0) = 36$$

then

$$f(x) > 36 \quad \text{if} \quad x > x_0$$
$$(x) < 36 \quad \text{if} \quad x < x_0.$$

Hence we must solve

$$f(x_0) = 36.$$

Square both sides

$$3x_0+2\sqrt{2x_0^2-x_0-1}=1296$$
$$2\sqrt{2x_0^2-x_0-1}=1296-3x_0.$$

Square again

$$8x_0^2-4x_0-4=[1296-3x_0]^2.$$

The solution of this is

$$x_0=3886\pm 3663.52^-$$

the + is rejected as inapplicable.

$$x_0=222.48^+$$
$$\therefore\quad x\gtrless 222.48^+.$$

There is no rational solution.

2103. *Proposed by Hugo Brandt, University of Md.*

Find the value of

$$\int_{2\cos A}^{1}\frac{a\,dx}{\sqrt{1-a^2x^2}}\quad\text{for}\quad a=\sin A.$$

Solution by A. MacNeish, Chicago, Ill.

$$\int_{2\cos A}^{1}\frac{a\,dx}{\sqrt{1-a^2x^2}}=\int_{2\cos A}^{1}\frac{dx}{\sqrt{\dfrac{1}{a^2}-x^2}}$$
$$=[\text{arc sin } ax]_{2\cos A}^{1},\quad\text{for}\quad a=\sin A,$$
$$=[\text{arc sin }(\sin A\cdot x)]_{2\cos A}^{1}$$
$$=\text{arc sin }(\sin A)-\text{arc sin }(2\sin A\cos A)$$
$$=\text{arc sin }(\sin A)-\text{arc sin }(\sin 2A)=A-2A=-A.$$

Hugo Brandt gave $-A$, $3A-\pi$, $\pi-3A$ and A as possibilities, with $-A$ and $3A-\pi$ as applying. Max Beberman and V. C. Bailey also offered solutions.

2014. *Proposed by August Leecher, Syracuse, N. Y.*

Solve the system

$$(x+y)^3+(x+y)=30 \tag{1}$$
$$x-y=1 \tag{2}$$

Solution by Herbert Janson, San Antonio

Solving (1) we obtain

$$x+y=3 \tag{3}$$

Solving (2) and (3) we obtain

$$x=2$$
$$y=1$$

Then we have

$$(x+y)^2+3(x+y)+10=0 \tag{4}$$

Solving (4):

$$x+y=\frac{-3\pm\sqrt{31}\,i}{2} \tag{5}$$

From (2) and (5) we obtain

$$x=\frac{-1\pm\sqrt{31}\,i}{4}$$

$$y=\frac{-5\pm\sqrt{31}\,i}{4}$$

Other solutions were offered by A. MacNeish, Chicago; Francis L. Miksa, Aurora, Ill.; V. C. Bailey, Evansville, Ind.; Exa O'Daye Hardin, Houston, Texas; August Leecher, Syracuse, N. Y.; Mary Paula, Plymouth, Mich.; Grace Levitan, Logan, W. Va.; Irvin L. Bailey, Tiffin, Ohio; Richard Scibby, Milwaukee; Max Beberman, Shanks Village, N. Y.; Margaret Joseph, Milwaukee, Wis.; W. R. Warne, Dayton, Ohio; Hugo Brand, University of Maryland; D. McLeod, Winnipeg, Canada.

2105. *Proposed by Bro. Felix John, Philadelphia, Pa.*

A man starts on a journey at 40 m.p.h. and reduces his speed by 2 miles every hour for an integral number of hours. If he had maintained the original rate, the journey would have taken $2\frac{3}{4}$ hours less. What was the distance traveled?

Solution by Grace Levitan, Logan, W. Va.

Let d = distance traveled and x = number of hours required. Then

$$d=40+38+36+34+\cdots+[40-2(x-1)] \qquad (1)$$

The right-hand member of (1), an arithmetic progression, may be summed as

$$d=\frac{x}{2}\{40+[40-2(x-1)]\}$$

or, reducing,

$$d=41x-x^2. \qquad (2)$$

From the second statement of the problem,

$$d=40\left(x-\frac{11}{4}\right).$$

Equating the values of d in (2) and (3) yields

$$41x-x^2=40x-110$$

or

$$x^2-x-110=0 \qquad (4)$$

The only positive root of this equation is

$$x=11 \text{ hours}.$$

Substituting in (3) gives

$$d=330 \text{ miles}.$$

Solutions were also offered by Exa O'Daye Hardin, Houston, Texas; M. I. Chernofsky, New York; Ronald Henderson, Pine Mountain, Ky.; Margaret Joseph, Milwaukee; Felix John, Philadelphia; W. R. Smith, Sutton's Bay, Mich.; Max Beberman, Shanks Village, N. Y.; A. MacNeish, Chicago; Francis L. Miksa, Aurora, Ill.; D. McLeod, Winnipeg, Canada.

2106. *Proposed by C. W. Trigg, Los Angeles City College.*

Using the nine digits (zero excluded) once each, form three numbers a, b, c,

such that $a+b=c$ and c is a perfect sixth power.

Solution by the Proposer

Since the nine digits are to be used once and only once, c must contain exactly three digits, so $c=729=3^6$. The possible combinations of the remaining digits which will properly form a and b are then $143+586=146+583=183+546=186+543=729$.

A related curiosity is $24137569=17^6$, in which the sum of the digits of 17 is 8, which together with the digits of the 6th power covers the nine digits.

Solutions were also offered by A. MacNeish, Chicago; Francis L. Miska, Aurora, Ill.; V. C. Bailey, Evansville, Ind.; M. I. Chernofsky, New York; Mary Paula, Plymouth, Mich.; Grace Levitan, Logan, W. Va.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high schoo classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2105. *Frank Jandrasi, Allentown, Pa.*

PROBLEMS FOR SOLUTION

2119. *Proposed by V. C. Bailey, Evansville, Ind.*

Prove that

$$\cos^4\frac{\pi}{9}+\cos^4\frac{2\pi}{9}+\cos^4\frac{3\pi}{9}+\cos^4\frac{4\pi}{9}=\frac{19}{16}$$

2120. *Proposed by Felix John, Ammendale, Md.*

Solve for x:

$$\tan x+2\tan 2x+4\tan 4x=\cot x$$

2121. *Proposed by C. W. Trigg, Los Angeles City College.*

Find the unique number of five digits of the form $abccc$ whose square diminished by one is a permulation of the digits $1, 2, 3, \cdots, 9$.

2122. *Proposed by C. W. Trigg, Los Angeles City College.*

If the sides of a right triangle are integers, then the radii of the inscribed and escribed circles are also integers.

2123. *Proposed by L. W. St. John, Millard, Mo.*

Find a necessary and sufficient condition that the roots of $x^3+fx^2+qx+r=0$, taken in same order shall be in geometric progression.

2124. *Proposed by Bessie Spillman, Dobbs' Ferry, N. Y.*

If $\cos A+\cos B=4\sin^2 C/2$, where A, B, C are angles of a triangle, show that the sides a, b, c are in arithmetic progression.

If the power to do hard work is not talent it is the best possible substitute for it.—Garfield.

BOOKS AND PAMPHLETS RECEIVED

American High School Biology, by Charlotte L. Grant, *Head of Department of Biological Science, Oak Park Township High School, Oak Park, Illinois;* H. Keith Cady, *Instructor of Biology, Oak Park Township High School, Oak Park Illinois;* and Nathan A. Neal, *Formerly Cleveland, Ohio, Public Schools.* Cloth. Pages xiii+888. 15×23.5 cm. 1948. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $3.28.

Plenty of People, by Warren S. Thompson, *Scripps Foundation for Research in Population Problems.* Revised Edition. Cloth. Pages xiv+281. 14×21 cm. 1948. The Ronald Press Company, 15 E. 26th Street, New York 10, N. Y. Price $3.50.

Microbes Militant: A Challenge to Man, by Frederick Eberson, Ph.D.' M.D., *Assistant Chief, Laboratory Service, Veterans Administration Medical Teaching Group, Kennedy Hospital, Memphis, Tennessee.* Cloth. Pages x+401. 15.5×23 cm. 1948. The Ronald Press Company, 15 E. 26th Street, New York, 10, N. Y. Price $4.50.

Exploring Electricity, by Hugh Hildreth Skilling, Ph.D., *Professor of Electrical Engineering, Stanford University.* Cloth. Pages viii+277. 14.5×21 cm. 1948. The Ronald Press Company, 15 E. 26th Street, New York 10, N. Y. Price $3.50.

Principles of Physics. III Optics, by Francis Weston Sears, *Professor of Physics, Massachusetts Institute of Technology.* Third Edition. Cloth. 369 pages. 15×23 cm. 1948. Addison-Wesley Press, Inc., Kendall Sq. Bldg., Cambridge 42, Mass. Price $4.50.

Radar Primer, by J. L. Hornung, *Commander U.S.N.R., Supervisor of Radio-Electronics, Walter Hervey Junior College,* New York City. Cloth. Pages vi+219. 13.5×20.5 cm. 1948. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $2.80.

Practice in Using Arithmetic, Books 1 and 2, by Virgil S. Mallory, Dennis H. Cooke, and Mary L. Brownfield. Paper. 21.5×28 cm. Book 1 has 80 pages, Book 2 has 96 pages. 1948. Benj. H. Sanborn and Company, 221 East 20th Street, Chicago 16, Ill. Price 68 cents each.

Employment Opportunities in the Navy Department for Scientists and Technicians, Issued by the Navy Department. Paper. 91 pages. 20.5×26.5 cm. July 1948. Navy Department, Washington 25, D. C.

BOOK REVIEWS

Astronomy, A Textbook for Colleges, by William Lee Kennon, Ph.D., *Professor of Physics and Astronomy in the University of Mississippi.* Cloth, Pages vii+737. 15.5×23 cm. 1948. Ginn and Company, Statler Building, Boston 17, Mass. Price $5.50.

The material of this new text for college students is separated into three major parts: Part I, The Apparent Motions of the Heavenly Bodies and Their Geometrical Representation is discussed in nine chapters; Part II, The Solar System, 12 chapters; Part III, The Light of the Stars, 10 chapters. There are in addition a 15-page Guide to the Observation of the Heavenly Bodies and an Appendix of 9 pages.

The book is much longer than most other elementary texts of astronomy but the author has attempted to provide a briefer course by setting certain topics in smaller type to be omitted if a shorter course is needed. To provide the many

students, who have not had the basic courses in physics and mathematics, with a satisfactory background certain additional material from these subjects is freely discussed. The text is well illustrated by pictures and diagrams, each with a good legend. Each chapter is followed by a brief set of questions, a list of topics for further study, and an excellent set of references. The discussions are usually clear and sufficiently complete for the general student. Unfortunately a number of serious errors occur which could have been readily corrected had a careful reading of proof been made. One or two examples will be sufficient to illustrate: on page 306 a plus sign is used in the Fitzgerald formula; on page 528, Fig. 24.14. "The relative radii of the orbits of several of the giant stars . . . instead of "The relative radii of several of the giant stars. . . . Careless errors such as these should not occur in a textbook for beginners.

G. W. W.

Swope's Lessons in Practical Electricity, by Erich Hausmann, E.E., Sc.D., *Thomas Potts Professor of Physics and Dean of the College, Polytechnic Institute of Brooklyn.* Eighteenth Edition, Revised and Enlarged. Cloth. Pages v+769. 15×23 cm. 1948. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $4.80.

This is the eighteenth edition of a book that has been a great success for almost fifty years. The main features of the book have been retained; a small amount no longer so essential has been eliminated or shortened; much new material has been added to bring the theory and applications up to the present time. This includes the most recent ideas of the electron as the unit of electricity and the additional particles that make up the atom; more emphasis on inductance and capacitance in the study of alternating current circuits; additional emphasis on radio including a study of multi-electrode tubes, new types of circuits, frequency modulation, television, loran and radar equipment and use. The other general features of the early editions of the text have been retained and improved. These include clear diagrams thoroughly labeled and explained, excellent problems completely worked out to show the use of electrical equations and the methods of computation. Excellent sets of questions and problems follow each chapter to give the pupil a chance to test his comprehension of the material just studied. This revision has now brought this excellent text up to date and insured its life as an active classroom text for years to come.

G. W. W.

Television and F-M Receiver Servicing, by Milton S. Kiver. Paper. Pages iv+212. 21×28 cm. 1948. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price. $2.95.

This new manual is just what the service man is looking for—a guide to the location of faults in the set and directions for making the necessary repairs. Familiarity with A-M receivers is first necessary. Then this book takes over, giving complete steps in the procedure for diagnosing and making repairs on all F-M circuits and television receivers. The language is clear and compact. The book is well illustrated with photographs and circuit diagrams. The only mathematics necessary is the ability to compute the proper lengths of transmission lines and antennas. It is well arranged for either individual or class use. The modern service man cannot get along without the information given.

G. W. W.

Methods of Algebraic Geometry, by W. V. D. Hodge, M.A., F.R.S., *Lowndean Professor of Astronomy and Geometry, and Fellow of Pembroke College, Cambridge,* and D. Pedoe, B.A., Ph.D., *Sometime Charles Kingsley Bye-Fellow of Magdalene College, Cambridge.* Volume I, Book I: Algebraic Preliminaries; Book II: Projective Space. Cloth. Pages viii+440. 14×22 cm. 1947. Cambridge University Press, Cambridge, Price $6.50.

Although this book could be used as a text in upper division or graduate work, it is more likely to be used as a reference work. The work is designed to bring together in one place material relative to the foundations and methods of modern algebraic geometry. Book I of this volume, consisting of 173 pages, is devoted to topics of pure algebra such as rings and fields, matrices, determinants, algebraic dependence, and algebraic equations. Although much of this material will be found in standard works on modern algebra, the authors state that some of the material has not previously been published.

Book II, covering slightly over 250 pages, presents definitions of projective space from both the algebraic and synthetic viewpoints, and compares these in some detail. However, the chapter presenting the synthetic definition is a unit in itself, and could be omitted. The last three chapters are devoted to Grassmann coordinates, collineations, and correlations. There is a brief bibliography of twelve references.

As is true with many English works, the treatment is exceptionally complete and rigorous as contrasted with American undergraduate texts; the typography is excellent and the paper of better quality than is the case with some recent books.

CECIL B. READ
University of Wichita

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ANALYTIC GEOMETRY, by Clyde E. Love, Ph.D., *Professor of Mathematics in the University of Michigan.* Fourth Edition. Cloth. Pages xi+306. 13×20.5 cm. 1948. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

This is the fourth edition of a text which has been widely used. Most instructors will be interested in the changes which have been made. The author states that a definite effort has been made to make the text easier reading for the student, and to a large extent the desired result seems to have been achieved. As contrasted with the third edition, there has been marked reduction in the space devoted to certain topics. The treatment of the circle is reduced from sixteen to seven pages; material eliminated includes work on common chords, tangents, radical axis. The material on conic sections has again been radically reduced, including omission of work on diameters, poles and polars, and the customary treatment of tangents. On the other hand, there had been marked addition of material, perhaps the most striking being a chapter on the derivative, including the general power formula, the formula for the derivative of a product, and differentiation of implicit functions. This leads to two chapters, one on tangents and normals, and one on polynomial graphs, including work on maxima and minima. A considerable portion of this work has customarily been found in elementary calculus, whether time or the desire of the instructor will permit its inclusion in analytic geometry is another question. However, since this material is a self contained unit, it may be omitted. Again, chapters which could be omitted if desired cover work on trigonometric functions, exponentials and logarithms; empirical equations; families of curves (more extensive than usual, as for example families of conics through four points). The material on solid analytic geometry has additional work on sketching of solids, on the other hand some work of the third edition is deleted—for example the omission of the proof that certain quadrics are doubly-ruled. The text retains the dual index, one for plane, the other for solid analytic geometry.

CECIL B. READ

COLLEGE ALGEBRA, by Frederick S. Nowlan, Ph.D., *Professor of Mathematics, University of British Columbia* (*Visiting Professor, University of Illinois, Chicago Undergraduate Division, 1947–48*). First Edition. Cloth. Pages xiv+371. 16×23 cm. 1947. McGraw Hill Book Co., Inc., New York. Price $3.00.

The reviewer for several years has expressed the point of view that there is

no reason to give an incorrect definition or one which is not completely rigorous, when a correct, rigorous definition is possible and within the comprehension of the student. To an exceptional degree, this text is satisfactory in this respect. The author states his belief that incompleteness or inexact statements increase the difficulty of the subject for the average student.

The material included covers all customarily found in a college algebra text, with some additional topics that are not usual. The careful review of elementary material, the completeness with which new topics are introduced, the many worked examples, all give the impression of sound scholarship. In a couple of places, the footnote which suggests that certain material may be replaced with an alternative treatment may lead the student to think that logical development of the subject matter may be of minor importance. It must be admitted that no single course of one semester could treat completely all the subject matter of the text.

Some of the less common features include the treatment of continued fractions and their use in finding solutions of linear indeterminate equations in two unknown; extensive treatment of ratio and proportion, in particular the treatment of continued proportion; the discussion of the binomial expansion for a fractional or negative exponent; the definition of complex numbers in terms of real number pairs; more extensive work than usual in the theory of equations; the treatment of multiplication of determinants.

It does not detract from the general excellence of the text to mention certain relatively minor details which did not appeal to the reviewer: on page 57 the variation in hourly temperature from 8 A.M. until 4 P.M. appears as a linear graph—it is indeed doubtful if the weather man ever has such an ideal situation; on page 71 the value of y as obtained from three linear equations at first sight appeared to be a matrix quotient, since both numerator and denominator consist of three rows of five columns of numbers each; on page 164 a statement is made about the mantissa of a logarithm which is only true for common logarithms; a footnote on page 257 discusses the phrase *necessary and sufficient condition* without pointing out that a condition may be sufficient but not necessary, and vice versa. In the note on pages 169 and 170, relative to interpolation when a tabular difference is halfway between two integers, it is stated that when we wish a product such as 7 log 2943, we employ the tabular difference 4.5, multiply logarithm by 7, then apply the rule. From the logical point of view, one wonders what is done with 7 log 5006—does one use the tabular difference 4.8, multiply by 7, then round, or round first and then multiply? No example could be found which would answer this question.

There seems to be in most cases an ample supply of problems, although in a few spots the supply may be inadequate if alternate assignments are needed each semester. Answers are provided to roughly one half of the exercises.

CECIL B. READ

NUMBER THEORY AND ITS HISTORY, by Oystein Ore. *Sterling Professor of Mathematics, Yale University.* First Edition. Cloth. Pages x+370. 15×20.5 cm. 1948. McGraw-Hill Company, Inc. 330 W. 42nd Street, New York 18, N. Y. Price $4.50.

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This book was written as a text book intended for college juniors and seniors. The historical aspect is much more prominent than in most books in number theory. The text would require less mathematical background than many texts; a large portion of the material could be read with only college algebra as a basis.

This book would prove a very valuable addition to any mathematical library even if it is not used as a text. Some of the topics which would not only interest the teacher but which would no doubt be within the grasp of a good high school senior are: Prime Numbers, Indeterminate Problems, Congruences, the Classical Construction Problems. The student or teacher interested in puzzle problems will find the chapter on Diophantine Problems interesting both from the mathe-

matical and historical viewpoint. The author treats the laws of combination in considerable detail and points out how these laws appear in other places than in pure number theory.

There is a bibliography at the end of most chapters and a general bibliography.

CECIL B. READ

INTRODUCTION TO THE DIFFERENTIAL EQUATIONS OF PHYSICS, by L. Hopf, *Professor at the Aachen Institute of Technology.* Translated by Walter Nef, *Professor at the University of Fribourg, Switzerland.* Cloth. Pages v+154. 10.5×16.5 cm. 1948. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.95.

There is a surprising amount of valuable material packed into this small book. About one third of the material covers ordinary differential equations, the balance of the treatment considers partial differential equations. The discussion is primarily from the viewpoint of the physicist, rather than from the point of view of pure mathematics.

The treatment is based upon a background of integral calculus, but in some spots the reader will need to proceed rather carefully to grasp the concepts presented. The method of treatment utilizes vector analysis, and the concepts of vector analysis are developed when needed for the problem under consideration. In the latter portion of the book some material frequently found in texts on functions of a complex variable is presented.

This book should be of value for one who has had no formal work along this line, and wishes to do some independent reading. There are no problems for solution; from this point of view it might be considered not suitable for class use as a text.

The work is particularly valuable for its discussion of the physical significance of certain mathematical concepts.

CECIL B. READ

GENERAL AND APPLIED CHEMISTRY, by Arnold J. Currier, *Associate Professor of Chemistry;* and Arthur Rose, *Associate Professor of Chemical Engineering; both Professors at The Pennsylvania State College.* Cloth. Pages ix+275. 15×23 cm. 1948. McGraw-Hill Book Company, Inc., New York 18, N. Y. Price $3.00.

This textbook is designed primarily for students in the applied sciences such as agriculture, engineering, and home economics. The book deals primarily with the most commonly recognized material on non-metals and metals. Special attention is devoted to fertilizers, foods, and fuels.

It is noteworthy and refreshing to see a college text in the field of chemistry place stress upon the application of principles to the solution of problems. For example, the correction of a gas volume for changes in temperature and pressure is presented in such a manner that the student must "think through" the problem, rather than rely upon conventional formulae.

Exercises are provided throughout the text at a point where application will bring results. This is a desirable departure from the "end of the chapter exercise."

The authors have succeeded in producing an understandable and useful text for students who need some work in chemistry to supplement their work in the various applied sciences.

KENNETH E. ANDERSON

THE CHEMICAL FORMULARY, VOLUME VIII, H. Bennett, Editor-in Chief. Cloth. 14×21 cm. Pages xxiv+448. 1948. Chemical Publishing Co., Inc., Brooklyn, N. Y. Price $7.00.

This volume is the eighth in a series of "Chemical Formulary." Each volume is unique in that there are no duplications from volume to volume. All eight volumes

constitute "a collection of valuable, timely, practical, commercial formulae and receipes for making thousands of products in many fields of industry."

Volume VIII contains twenty-one chapters on such products as Adhesives; Emulsions and Dispersions; Farm and Garden Preparations; Paint, Varnish, Lacquer and Other Coatings; and numerous other areas. A few days ago someone desired the ingredients for acid proofing a tank. "The Chemical Formulary" gave the answer in the chapter on "Paint, Varnish, Lacquer, and Other Coatings."

Colleges and industrial establishment should find these volumes a useful and practical addition to their libraries.

KENNETH E. ANDERSON

COMMERCIAL ARITHMETIC, A TEXT FOR STUDENTS IN THE BUSINESS OR GENERAL COURSE, by Virgil S. Mallory, *Professor of Mathematics and Teacher in the Demonstration School, State Teachers College, Montclair, New Jersey;* William M. Polishook, *Associate Professor and Director of Business Education, Temple University;* Ivan E. Chapman, *First Assistant Superintendent, Public Schools, Detroit, Michigan;* and S. Herbert Starkey, Jr., *Head, Mathematics Department, High School, Madison, New Jersey.* Cloth. Pages vii+510. 13.5×20.5 cm. 1948. Benj. H. Sanborn and Company, 221 East 20th Street, Chicago 16, Ill. Price $1.96.

An introductory course prepared for secondary or business school students· The arithmetic content is reviewed and diagnostically tested in the opening chapter. References are provided to practice materials, and self rating scales are used for test performance. The second chapter develops the meaning of percentage, and covers the three types of percentage problem. The third chapter presents the interpretation and construction of line, bar, circle, and pictorial graphs. The final chapter of the text includes a review by examples and the practice materials for the arithmetic operations covered in the first three chapters. The balance of the text consists of selected topics from the business world. These are interpreted for the student and the problem materials utilize the arithmetic content previously developed. The authors state that these topics have been chosen on the basis of personal experience in the teaching and directing of courses of this type, and that samples of all materials used were checked with business men for accuracy in relation to current business practices. The major emphasis seems to be on the individuals contact with these topics in personal living, rather than from a vocational aspect.

The various units are very carefully worked out and utilize student activity to a large degree. The vocabulary and general explanatory material is clearly aimed at the student and should prove to be of value for self study use. Many illustrations are shown of actual business forms. The problem materials are extensive, and graded in difficulty. Chapter and review tests are provided for each unit of work.

This is clearly a superior text for a course of this type.

W. K. McNABB
Hockaday Junior College,
Dallas, Texas

FUNDAMENTALS OF STATISTICS, by J. B. Scarborough, Ph.D., *United States Naval Academy*, and R. W. Wagner, Ph.D., *Oberlin College.* Cloth. Pages viii +142. 16×24 cm. 1948. Ginn and Company, Boston. Price $2.50. OK

This book presents the fundamental principles and techniques of statistical analysis. It does not, however, limit itself to those phases for included also are some of the more important ideas and methods of elementary mathematical statistics. Students who have had the usual college mathematics courses through the elementary calculus will have had the kind of a mathematical background that will enable them to get much from the materials of this book. Those persons

desiring a relatively brief but fairly rigorous treatment of statistical method should find their needs adequately met. The mathematical prerequisites make it possible to discuss continuous distributions simply and concisely. *A priori* probability is discussed in an appendix because many students will have studied the topic in an algebra class, however, this material should be reviewed for obvious reasons. The topic of *curve fitting* is not considered because the topic is usually included in textbooks on analytic geometry; and *time series* and *small sample distributions* have been left out for the sake of brevity.

The major statistical areas treated are: representation of data, averages, measures of dispersion, comparison and distributions, correlation, probability functions, the normal curve and a generalization, and sampling. Necessary Tables, answers, and an index are the added features of the book.

JOSEPH J. URBANCEK
Chicago Teachers College

INSTRUCTIONAL FILMS HELPED BRING OUT THE KOREAN VOTE

The story comes back from the Orient of how one of the world's newest educational devices helped to return democracy to one of the world's oldest civilizations—Korea, whose last 40 years of her 4000 were spent under Japanese domination.

Shortly before the recent elections in South Korea, American Military Government officials sent an SOS to the Department of the Army in Washington. They requested that they be immediately sent the latest and most effective educational films that could be found. Films, they said, were needed to help "bring out the vote" and to educate the Koreans in democratic voting procedures. The coming elections were of vital interest to Korea and to the entire world—and the Koreans didn't know how to vote!

The Army flew three films to Seoul, Korea. One of them, already in widespread use in our own schools, was "How We Elect Our Representatives," produced by *Coronet*. The others were "Ballot Boxes," a Canadian production, and "Tuesday in November," which had been produced for the Department of State. In Seoul, the films were loaded aboard a mobile unit and sent on a high speed tour of towns and villages throughout Korea. Day and night, the unit made countless stops to show its films. There had not been time to process them with sound tracks in the Korean language so at every exhibition an interpreter gave his commentary through a public address system. At each stop, thousands of villagers thronged about, watching and listening. In one province alone, Chong Chun, adjoining the 38th parallel, the films were shown to more than 90,000 Koreans in 10 days. The lesson they conveyed "took."

On election day, more than 80% of Korea's eligible voters crowded the pools. They knew what voting meant, and they knew how to do it. Military government officials said that the films were invaluable in helping bring to South Koreans the independence and democracy for which they had waited so long.

SLIDEFILMS IN COLOR ON WATER LIFE NOW AVAILABLE

A new series of discussional slidefilms on fresh and salt-water life has been added to The Jam Handy Organization's "Science Adventures" series. These films colorfully present basic information about many animals and plants found in the water. Each film is organized into several units, each suitable for presentation during one period. They are designed for science classes, grades 4, 5, 6, 7, 8; biology classes, junior and senior high school; and for oral reading classes. All of the seven slidefilms are in natural color. For details address The Jam Handy Organization, 2821 East Grand Boulevard, Detroit 11, Michigan.

Two unfortunate attitudes have grown-up with regard to general mathematics in the secondary school.

1. That general mathematics is a course for dull normals or pupils of low ability to do mathematics.

2. That a one-year course in the ninth grade will serve the purpose for most pupils who take it.

Both of these attitudes are wrong and it is high time we do all that we can to correct them.—W. D. REEVE.

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